Manufacturing Competitiveness in Times of China:
Evidence from South Africa

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Abstract

The main objective of this thesis is to shed new light on the effects of the dramatic increase in China's export and production capacity on the competitiveness of the South African manufacturing sector. The analysis focuses on the post-apartheid period, when China's global expansion accelerated and its bilateral relations with South Africa intensified, giving rise to widespread concerns about the effects on South Africa's development prospects.

This thesis adopts a multi-methods research strategy. Its main body consists of three chapters, each taking a distinct approach to providing new evidence on the research subject. First, two econometric studies, incorporating key aspects of evolutionary and structuralist economics, analyse the impact of Chinese import penetration on the growth dynamics of South Africa-based manufacturing firms (Chapter 3) and on South African exports of medium- and high-technology products to third countries (Chapter 4). Second, a mixed methods case study explores the effects of the rise of China on South African mining equipment suppliers (Chapter 5). This analysis is the result of nine months' fieldwork and builds on a novel analytical framework integrating insights from global value chain research, the technology capability framework, and international business and general management literature. Chapters 3 to 5 are preceded by an introduction (Chapter 1) and some methodological considerations (Chapter 2), and followed by conclusions (Chapter 6).

This thesis finds that the rise of China has exerted a strong competitive pressure on the South African manufacturing sector. South Africa-based firms have seen their growth potential constrained due to the increasing penetration of Chinese imports. South African exports of medium- and high-technology products to third markets have experienced a decline, due to increasing Chinese exports in the same product categories and destinations. Finally, the rise of China has been identified as a key factor behind the ongoing marginalisation of South Africa as a strategic location for innovation in, and the production of, mining-related technologies. Although this thesis focuses on a specific, and admittedly limited, set of trade- and investment-related impacts of the rise of China, it shows that this phenomenon has intensified the challenges faced by South African manufacturing, increasing the urgency for strengthening domestic capabilities, particularly in some more technology-intensive sectors, by means of targeted industrial policy measures.

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«And all the lives we ever lived
And all the lives to be
Are full of trees and changing leaves.»[§]

§ "A Garden Song" by Charles Isaac Elton, in *To the Lighthouse* by Virginia Woolf.

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List of abbreviations

BRICs	Brazil, Russia, India, China
CAD	Computer Aided Drawing
CAGR	Compound Annual Growth Rate
CapEx	Capital Expenditure
CCRED	Centre for Competition, Regulation and Economic Development
CEO	Chief Executive Officer
CGE	Computable General Equilibrium
CIF	Cost, Insurance and Freight
CIT	Corporate Income Tax
COMRO	Chamber of Mines Research Organisation
COO	Chief Operating Officer
CoPS	Complex Product System
CPI	Consumer Price Index
CSIR	Council for Scientific and Industrial Research
CTO	Chief Technical Officer
DMR	Department of Mineral Resources
DST	Department of Science and Technology
DTI	Department of Trade and Industry
DVA	Domestic Value Added
ECIC	Export Credit Insurance Corporation
ECLAC	Economic Commission of Latin America and the Caribbean
EPC(M)	Engineering Procurement & Construction (Management)
ESI	Export Similarity Index
EU28	European Union Group of 28
FDI	Foreign Direct Investment
FEA	Finite Element Analysis
FOB	Free on Board
FOCAC	Forum on China–Africa Cooperation
FVA	Foreign Value Added
G20	Group of Twenty
GDMC	Global Diversified Mining Company
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GMM	General Methods of Moments
GPN	Global Production Network
GTAP	Global Trade Analysis Project
GVC	Global Value Chain
HS	Harmonised System
IDB	Inter-American Development Bank
IDC	Industrial Development Corporation
ILO	International Labour Organisation
IPAP	Industrial Policy Action Plan
ISIC	International Standard Industrial Classification
IV	Instrumental Variable
JV	Joint Venture
KIMS	Knowledge Intensive Mining Supplier
LHD	Load Haul and Dump Machine

LMIC	Low and Middle Income Country
M&A	Merger and Acquisition
MCSA	Mineral Council South Africa
MD	Managing Director
MEGVC	Mining Equipment Global Value Chain
MEMSA	Mining Equipment Manufacturers of South Africa
MFA	Multifibre Arrangement
MGVC	Mining Global Value Chain
MHT	Medium and High Technology
MMP	Mandela Mining Precinct
MRO	Maintenance, Repair and Operation
MVA	Manufacturing Value Added
NGO	Non-Governmental Organisation
NIE	Newly Industrialised Economy
ODI	Overseas Direct Investment
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OLS	Ordinary Least Squares
OpEx	Operational Expenditure
PAYE	Pay As You Earn
R&D	Research and Development
RCA	Revealed Comparative Advantage
RCT	Randomised Control Trial
SACEEC	South Africa Capital Equipment Export Council
SACU	Southern African Customs Union
SADC	Southern Africa Development Community
SAIMM	Southern African Institute of Mining and Metallurgy
SAMPEC	South African Mineral Processing Equipment Cluster
SARS	South African Revenue Service
SETA	Sector Education and Training Authority
SGA	Strain Gauge Analysis
SIC	Standard Industrial Classification
SITC	Standard International Trade Classification
SNA	System of National Accounts
SOE	State Owned Enterprise
TiVA	Trade in Value Added
TFS	Transnational First-tier Supplier
TSLS (2SLS)	Two Stages Least Squares
TTM	Trailing Twelve Months
TVA	Trade in Value Added
TVET	Technical Vocational Education and Training
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Organisation
USD	United States' Dollar
WDI	World Development Indicators
WIOD	World Input-Output Database
WOFE	Wholly Owned Foreign Enterprises
WTO	World Trade Organisation

Chapter 1

Introduction

1.1 Introduction

This thesis aims to study the impacts of the dramatic increase in China's export and production capacity on the industrial development dynamics of South Africa. The analysis extends until late 2019, before the COVID-19 crisis hit. It focuses on the period after the end of apartheid, when the global expansion of China accelerated and its bilateral relations with South Africa intensified, giving rise to widespread concerns within and beyond academia about its potential negative effects on that country's development prospects. Indeed, the growing and evolving role of China in global and South-South trade and value chains during the past three decades has been seen as exacerbating the major structural transformation challenges faced by the South African economy.

The investigation conducted in this thesis revolves around three main contributions, represented by Chapters 3, 4 and 5. These chapters focus on different aspects of the phenomenon under analysis, and employ a variety of data sources and research methods to fill the key knowledge gaps identified in the related literature so far. To the best of my knowledge, this thesis is the first structured attempt at studying the role of the rise of China on South African industrial development trajectories by focusing on its heterogeneous effects at the level of firms (Chapters 3 and 5) and sub-sectors (Chapters 4 and 5), and by analysing the specific dynamics characterising relatively more technology-intensive industries (Chapters 4 and 5).

The rest of this introductory chapter is divided into four sections. Section 1.2 introduces the main motivation behind this research project. Section 1.3 presents the research questions, a set of research hypotheses and the methods employed to answer these questions. Section 1.4 briefly highlights the originality of the contributions contained in this thesis. Finally, Section 1.5 presents the thesis' structure and an extended summary of each subsequent chapter.

1.2 Motivation

1.2.1 The shifting geography of trade and investments: mainly a China story

Since the early 1990s, the so-called Global South[1] has achieved a much greater prominence in the global trade and investments landscape. In 2018, developing countries, at the aggregate level, accounted for 36% of the world's total merchandise exports and 41% of global foreign direct investment (FDI) outflows, up from a share of 14% and 5% in 1990, respectively. Furthermore, the relative importance of intra-developing countries (South-South) trade and investment flows has also risen significantly during the same period (UNCTAD, 2019a, 2019b and 2020; Gold et al., 2017; Horner and Nadvi, 2018). This evidence, in particular, has prompted a lively debate on the implications of these new geographies of trade and global value chains (GVCs), which are shifting away from the dominant North-South pattern (Kaplinsky and Farooki, 2011; Amighini and Sanfilippo, 2014; Sinkovics et al., 2014; UNCTAD, 2015; Horner, 2016; Horner and Nadvi, 2018), for the industrial development prospects of emerging economies. Nonetheless, although the developing world as a whole has gained a much more prominent role within the global economic arena, aggregate figures tend to hide considerable differences across economies.

Deeper analyses of official international and national statistics reveal that developing Asia, and specifically China, is at the core of the Global South's rising share in merchandise exports and foreign investment outflows directed either to the world or specifically to other developing countries. In fact, starting from a negligible share in the early 1980s, in 2018 China accounted for around 34% and 45% of total South-South merchandise and manufacturing exports, respectively, and for around one-third of total FDI outflows originating from developing countries (UNCTAD, 2019a, 2019b and 2020). Furthermore, according to official Chinese statistics, in 2017 slightly less than one-fifth of total Chinese

[1] The North-South categorisation used here builds on the terminology popularised by the Brandt Report, published in 1980, and aims to distinguish broadly between developed and developing economies, while acknowledging the existence of exceptions to this generalisation. Global South, in particular, refers to the lion's share of countries in Latin America and the Caribbean, Africa, transitional Eastern Europe and Central Asia, and developing Asia, including China. Specifically, I follow the UN classification of upper-middle- to low-income economies, i.e., the so-called low- and middle-income countries. The terms 'Global South', 'South', 'developing countries', 'emerging countries' and 'less developed countries' are used interchangeably throughout the text, while a distinction is generally made between 'low-income' and 'middle-income' economies.

outward FDI flows consisted of investments undertaken in developing countries (NBS, 2017).[2] Besides becoming much more integrated in global and South-South trade and value chains, China has also firmly established itself as a global industrial power, increasing its share of world gross domestic product (GDP) and manufacturing value added (MVA) dramatically. The former rose from less than 1% in the early 1980s to over 10% in 2018, and the latter from a negligible 3% in 1990 to slightly less than 25% in 2018 (Haraguchi et al., 2017; UNIDO, 2020). Between 2000 and 2018, China accounted for around a quarter of the total increase in world GDP and for half of the total increase in all developing countries' GDP. Over the same time period, the country also accounted for 35% of the total increase in world MVA and for about 56% of its increase in all developing countries (Lo, 2020; UNIDO, 2020).

The remarkable growth of China's export, investment and production capacity signals its increasing role in global and intra-developing countries value chains as both an efficient assembly and export platform, and an emerging producer and exporter of indigenous technology. In particular, the shifting trajectories in the geographies of trade and investments – with China being the key driver of such dynamics – do not necessarily reflect a situation in which lead firms from advanced countries are excluded from organising and controlling South-South and particularly China-South transactions (Horner and Nadvi, 2018). Indeed, over the past three decades, many multinationals headquartered in developed economies have reconfigured their production networks, shifting their focus towards China, an economy that offers an extremely large pool of low-cost labour, efficient manufacturers with rapidly growing productive capabilities, abundant raw materials, and a sizeable and booming domestic market. So, from a GVC perspective, lead firms from advanced economies still effectively govern a substantial share of China-South trade flows through their Chinese subsidiaries which, in turn, mainly serve as assembly and export platforms for foreign products and technologies (Gereffi, 2014 and 2015; Lee and Gereffi, 2016).[3]

[2] However, this figure may be an underestimate. The bulk of Chinese outward FDI flows is directed to Hong Kong (i.e., 57% in 2017). As outlined in the literature, Chinese subsidiaries in Hong Kong might, in turn, serve as holding companies investing in third countries or even back into China (Morck et al., 2008).

[3] In this respect, a closer look at FDI figures is particularly valuable for unpacking the value chain reshaping strategies carried out by leading multinationals from advanced economies. A new probabilistic approach developed by UNCTAD (UNCTAD, 2019b) to estimate the investment positions held by ultimate investors reveals that a significant share of South-South and China-South FDI is still ultimately undertaken and controlled by multinational companies from advanced economies, and channelled through developing countries' investments hubs.

However, alongside these value chain restructuring dynamics controlled by large multinationals from advanced countries, evidence of leading Chinese firms entering and upgrading along different global value chains is clearly emerging (Williamson and Zeng, 2009). While large Chinese companies still lag behind their competitors from advanced economies in terms of brand reputation and capabilities in many global industries (Brandt and Thun, 2010; Bruche and Hong, 2016; Safdar and Van Gevelt, 2020), they are reshaping competition and reconfiguring power dynamics in both global and intra-developing countries value chains in a number of different manufacturing sectors (Sturgeon and Kwakami, 2011; Lema et al., 2013; Zhang and Gallagher, 2016; Morris and Staritz, 2014; Bamber et al., 2016; Baker and Sovacool, 2017). Taking advantage of the large and segmented domestic market, and highly supportive and targeted government policies, these new actors have gradually entered and upgraded along multiple value chains (Lee, 2019), performing a variety of different functions according to the specific geographical scale of production networks, either global, regional or domestic (Yang, 2013; Horner and Nadvi, 2018). Many of these firms have gradually moved away from being assemblers of foreign products and technologies, evolving into components providers and, ultimately, into system integrators and original equipment manufacturers (OEMs), even in a number of advanced manufacturing sectors (Fu, 2016; Tassey, 2014; Zhou et al., 2016; UNCTAD, 2019b). The impressive upgrading trajectories of many of these companies in both global and South-South value chains are reflected in the increasing share of domestic value added (DVA) content in China's exports to both OECD (Organisation for Economic Cooperation and Development) and non-OECD economies. Between 2005 and 2016 these rose from around 70% to over 80% in the manufacturing sector, and from 65% to 78% in the subset of medium- and high-technology (MHT) industries (OECD-TiVA, 2018).

1.2.2 The impacts of the rise of China on the industrial development trajectories of other developing countries

The dramatic expansion of China's commercial and industrial capacity, and the country's ongoing upgrading along many global and South-South value chains, stimulated an active debate regarding the multifaceted nature of its impact on industrial development trajectories in the rest of the developing world. To guide this discussion, the literature has distinguished between trade- and investment-related competitive and complementary impacts affecting other developing countries either directly (i.e., within the strict boundaries of their bilateral relations with China) or indirectly, that is through third economies (Kaplinsky and Messner, 2008). These are summarised in Table 1.1 and discussed in more detail below.

Table 1.1. A framework for analysing the impacts of China on other developing countries (i.e., country ***x***).

Channel of interaction	Competitive		Complementary	
	Direct	Indirect	Direct	Indirect
Trade	Chinese imports might displace local producers in country *x*, with negative effects on output and employment.	Chinese exports may crowd out country *x*'s exports to third markets (i.e., Chinese and country's *x* exports in third markets are substitute).	Increased availability of cheap inputs and consumer goods in country *x*. Increasing exports to China (due to China's high demand for raw materials, natural resources).	Chinese exports may have a positive impact on country *x*'s exports to third markets (i.e., Chinese and country's *x* exports to third markets are complementary).
FDI	—	Competition for FDI inflows from third countries between China and country *x*.	Inward FDI from China to country *x*.	—

Source: Own elaboration, adapted from Kaplinsky and Messner (2008).

With respect to FDI, it has been argued that China's may have a direct complementary effect and an indirect competitive effect on other developing countries, representing both an opportunity and a risk for their future growth prospects. As far as the former effect is concerned, during the past three decades China has been an important and direct source of inward FDI for many developing countries (Frost, 2004; Kaplinsky and Morris, 2009; Gu, 2009; Chen and Peréz Ludeña, 2014). On the one hand, these investment inflows can drive a number of potential benefits for the recipient countries, including productivity and technology spillovers, valuable infrastructures, increasing demand for domestically produced inputs and increasing employment opportunities via linkage effects (Farole and Winkler, 2014; Wolf, 2016 and 2017). However, on the other hand, the interplay between investments and trade might also result in a number of direct or indirect competitive effects for the FDI-recipient economy and for third developing countries exporting to it. In fact, since China's outward investments flows have been found to be closely bundled with its exports, they can possibly result in increasing import penetration rates in the host economy (Kaplinsky and Morris, 2009; Morrissey, 2012; Fessehaie and Morris, 2013). Rising imports from China, in turn, might displace local producers and other developing countries' exporters in this market (Tull, 2006; Zeng and Williamson, 2007; Ferreira, 2009).

Another FDI-related competitive effect is represented by the indirect competition between China and other developing countries for the attraction of inward FDI originating from third economies. Since 1993, China has become the largest recipient of FDI inflows among developing countries and the second largest recipient in the world, after the United States (Oman, 2000). In 2018 it attracted USD 139 billion, with an increase of 4% compared to the previous year (UNCTAD, 2019b). Several multinationals from advanced economies have offshored assembly and production activities to China, attracted by the large pool of low-cost labour, the presence of efficient subcontractors with rapidly increasing productive capabilities, the abundance of raw materials, and the large, segmented and growing domestic market. The increasing indirect competitive pressure for global FDI inflows exerted by China has probably made it more difficult for other developing economies to attract investors from third countries (Kaplinsky and Messner, 2008).

With respect to trade interactions, a wider set of possible impacts has been identified. First, and similar to the FDI case, China's rising exports may exert a direct complementary effect on other developing countries. In fact, it has been stressed that China has been an important source of cheap inputs (Iacovone et al., 2013; He, 2013) and consumer goods (Morris and Ehinorn, 2008) for them. Specifically, with respect to capital goods imported from China, their direct complementary effect in other developing countries has been found to be relatively higher compared to technologies and machinery imported from advanced economies (He, 2013). Case evidence has revealed that in many instances Chinese-origin capital goods are relatively more accessible and profitable for users in less developed countries, and more appropriate to their operating conditions (Hanlin and Kaplinsky, 2016).

Another direct complementary effect is linked to the fact that China has also represented a large and fast-growing market for other developing countries' exports of raw materials and natural resources (Kaplinsky and Morris, 2008; Kaplinsky and Farooki, 2011). In principle, as underlined by Lo (2020), the massive improvement in net barter terms of trade in the rest of the developing world with respect to China observed over the 1998-2018 period might have provided emerging countries with substantial revenues to be channelled into productive investments, boosting the potential for industrial development. Admittedly, Teng and Lo (2019) found that this terms-of-trade effect has increased the productive investments and export sophistication of a number of low-income economies. However, overall, the sharp growth in Chinese demand for raw materials and natural resources has been found to have principally contributed to a renewed specialisation in commodity production and export for many developing countries (Kaplinsky and Morris, 2008; Kaplinsky et al., 2010; Jenkins, 2014 and 2015; Paus, 2019). This trajectory has revived concerns about 'primarisation' and 'deindustrialisation', and the loss of the dynamic benefits associated with an expanding manufacturing sector (Tregenna, 2016a).

Furthermore, the literature also underlines how the observed growth of global Chinese exports of manufacturing products had direct and indirect competitive effects on the domestic production systems of other developing countries, displacing local manufacturers and crowding out their exports to third markets (Giovannetti and Sanfilippo, 2009; Jenkins, 2014; Edwards and Jenkins, 2014 and 2015). These dynamics have, in turn, reinforced, in many cases, the deindustrialisation trajectories outlined above. As an example, these direct and indirect competitive effects have negatively affected many less developed countries that, over years, had devoted significant resources to the development of a domestic textile and clothing industry under the Multifibre Arrangement (MFA). After its expiration in 2005, many of them have seen their domestic sales and exports to third markets squeezed out due to the increasing competition from cheaper Chinese textile products (Jenkins, 2008a; Morris and Ehinorn, 2008; Kaplinsky and Morris, 2008; Qiu and Zhan, 2016; Abu Hatab, 2017).

In other instances it has been found that Chinese global exports had a complementary impact on other countries' exports directed to third markets. However, this has been mainly the case for exports of capital and high-technology products from upper-middle- and high-income economies, and reflects the role of China as a components' supplier, particularly within global and East Asian production networks led by industrialised countries (Eichengreen et al., 2007; Athukorala, 2009; Pham et al., 2017).

With specific reference to the trade-related interaction channel, overall, the rise of Chinese manufacturing exports has been found to pose a much more severe direct and indirect competitive threat to those developing economies whose production and export structures most resemble China's own. For example, descriptive evidence based on indices of export similarity has generally shown that the competitive threat which Chinese exports pose to other developing countries' exports to third markets has been confined to few, mainly Asian, economies (Meller and Contreras, 2003; Shafaeddin, 2004). Conversely, the competitive threat posed by Chinese exports on other developing countries' exports has been relatively limited. In fact, the trade profile of many less developed countries in Latin America and the Caribbean has been found to be largely complementary to that of China (Lall et al., 2005), while very few African countries export in the same sectors as China (Giovannetti and Sanfilippo, 2009). However, key exceptions in these regions are represented by a number of middle-income economies like Brazil, Mexico and South Africa which, over time, have generally displayed rising shares of manufacturing export under the China's competitive threat (Blazquez-Lidoy et al., 2007; Lederman et al., 2008; Jenkins, 2008b and 2014; Lall et al., 2005; Goldstein et al., 2006; Dussel Peters and Gallagher, 2013; Jenkins and Edwards, 2015).

In fact, China's structural transition from exporting low-technology goods (e.g., textile and clothing) to exporting more advanced products (e.g., machine tools), and from being essentially an assembly-export platform along GVCs to being a producer and an integrator of components and final goods, has caused concerns, especially for other middle-income countries trying to build or retain a competitive edge in more technologically advanced manufacturing sectors (Paus, 2019; Jenkins, 2014; Jenkins and Edwards, 2015). The growing and evolving role of China in global and South-South trade and value chains during the past three decades has been seen as a key factor exacerbating the major structural transformation challenges faced by many middle-income countries. Different studies have underlined how it may have contributed to limit the breadth and depth of the industrial development of a number of economies in this specific subgroup (Kaplinsky and Morris, 2008; Lall et al., 2005; Lall and Alaladejo, 2004; Jenkins and Barbosa, 2012; Jenkins, 2014 and 2015; Edwards and Jenkins, 2014 and 2015; Jenkins and Edwards, 2015), as well as their ability to keep pace with technological change and innovation and, thus, to move from a factor-driven to an innovation-driven model of growth (Paus, 2019; Andreoni and Tregenna, 2020).[4] That being said, additional detailed studies on the impact on middle-income countries of the rapidly rising role of China in global and South-South trade and value chains are needed to provide evidence that supports or challenges these claims.

Ultimately, however, even among the relatively more homogeneous subgroup represented by middle-income countries, each economy can be affected in a very different way by a

[4] The unprecedented rapid and sustained growth of China also highlights the structural disparity persisting between this country and the rest of middle-income economies. In this respect, it also questions the adequacy and analytical usefulness of the BRICs (i.e., Brazil, Russia, India, China) as a category of rising powers (Rothkopf, 2009; Jacobs and Van Rossem, 2014).

specific and complex combination of these direct, indirect, complementary and competitive effects, which may reinforce or contrast with each other during different time periods. The heterogeneity and disproportionate dynamics are explained by the pattern of interaction with China (i.e., the size and composition of these China-related effects), but also by country-specific factors, including differences in domestic policies (Wolf, 2016; Cheru and Oqubay, 2019). Furthermore, within economies and sectors, firms might be affected by trade- and GVC-related reorganisation dynamics in a very different way, based on their specific characteristics and capabilities, as underlined by evolutionary, resource based and capability theories of the firm (Dosi et al., 1990 and 2000; Lall, 1992 and 1999; Teece, 1986; Lin and Chang, 2009). The range of possible and heterogenous emerging scenarios between and within economies and sectors provides adequate grounds for adopting a single-country study research approach to this subject matter. Such an investigation strategy, indeed, allows for the exploration of different aspects of the multifaceted phenomenon under analysis here. In particular, it is well suited for shedding new light on a number of trade- and GVC-related trends and dynamics in an individual country context, taking into account its specificities and focusing on different units of analysis at various levels of aggregation (i.e., firms, sectors, sectoral value chains).

1.2.3 Why South Africa?

South Africa provides an excellent policy-relevant case study in this respect. Chinese competition is a relatively new but increasingly important policy challenge for the South African economy, which interacts to an important extent with the overall long-standing primarisation and premature deindustrialisation dynamics going on in the country. Since the end of apartheid in 1994, South Africa's increasing integration into the global economy has gone hand in hand with severe unemployment, poor growth performance and persistent structural transformation challenges (Rodrick, 2008; Jenkins, 2008c; Tregenna, 2012; Erten et al., 2019; Andreoni et al., 2021a). Although over the years South Africa has developed advanced production and export capabilities in a number of MHT manufacturing sectors, such as automotive and industrial machinery (Black, 2001; Kaplan, 2012; Andreoni et al., 2021a), it has failed to take forward its industrialisation process, and to diversify and upgrade the structure of its economy (Andreoni and Tregenna, 2020; Andreoni et al., 2021a; Zalk, 2021).

The lack of structural change in the country is captured by a number of measures and trends. First, the contribution of MVA to GDP fell by over a third, from 21% to 13%, between 1994 and 2019. The share of manufacturing employment in total employment has also registered a drop, from 15.1% to 9.3%, during the same period (Statistics South Africa, 2019a and 2019b; Quantec, 2020; Zalk, 2021).[5] Second, within manufacturing there has been a structural regression as growth in value added has been particularly pronounced only for natural resources-based sub-sectors. As an example, the value added within the coke and refined petroleum industry grew at an average compound annual growth rate (CAGR) of 4.9% between 1994 and 2019, compared to the 1.5% growth experienced by other more diversified manufacturing sectors (Statistics South Africa, 2019b; Quantec, 2020; Zalk, 2021). Third, the South African export basket has remained extremely undiversified, and it is still disproportionally skewed towards mineral and resource-based products. In 2019, these accounted for around 57% of South Africa's total merchandise exports (Zalk, 2021).

Following China's accession to the World Trade Organisation (WTO) in 2001, trade relations between South Africa and China have deepened rapidly. In 2009, China became South Africa's top export destination, surpassing the United States, and its largest supplier of imports, overtaking Germany. However, while South Africa's exports to China are primarily natural resources and processed raw materials, South African imports from China consist mainly of consumer products and, increasingly, of capital goods (Edwards and Jenkins, 2015). Furthermore, while during the mid-1990s China represented a major source of imports for South Africa in the traditional low-technology and labour-intensive sectors, such as textiles, clothing and footwear, by the 2010s Chinese import shares and penetration ratios had shifted towards medium- and high-technology products, such as machinery and equipment (Edwards and Jenkins, 2015; see also Chapter 3 on this). The surge in trade structure imbalances and the evolving composition of these bilateral trade flows have fed concerns both within and beyond academia about their impact on the deindustrialisation and 'primarisation' trajectories of the South African economy, and on its manufacturing production and employment (Edwards and Jenkins, 2015; Morris and Ehinorn, 2008) as well as on the future terms of engagement with China.

During the fifth Ministerial Conference of the Forum on China–Africa Cooperation (FOCAC) in 2012, held in Beijing, former South African President Zuma commented that such an unequal trade relationship between China and South Africa, based on the supply

[5] It is important to note, however, that at least part of this decline in the share of manufacturing jobs in South Africa is attributable to the domestic outsourcing of certain activities like cleaning and security from manufacturing to external specialised service providers (Tregenna, 2010).

of raw materials by South Africa, was unsustainable (Mail & Guardian, 2012). On the occasion of the seventh edition of the same event, in September 2018, President Ramaphosa re-emphasised the importance of balancing the structure of trade with China (South African Government, 2018). On the basis of these widespread concerns, shared by many South African and other regional stakeholders, including industry associations and trade unions, the negotiations for a free trade agreement between China and the South African Customs Union (SACU), first initiated in 2004, were subsequently abandoned. In that respect, many South African industry representatives, trade experts and policymakers have argued that a reciprocal free trade agreement with China, which did not allow for asymmetrical and sector-by-sector reductions in trade tariffs, would not have been in the interests of the country (Lennox, 2005; Langeni, 2012).

Similar to Chinese exports to South Africa, Chinese exports directed to third markets, both at the global level and in the sub-Saharan African region, have also experienced an impressive growth and increasing sophistication (Edwards and Jenkins, 2014; Jenkins and Edwards, 2015; see also Chapter 4 and 5 on this). China's increasing involvement in exports of diversified and advanced manufacturing products, in particular, is seen as a key factor that might prevent South Africa from capturing the gains of 'learning by exporting' these types of products (Bell et al., 2018) and undermine the country's global export prospects, as well as its position as a regional gateway for foreign and local investors and traders to access the rest of the African continent (Edwards and Jenkins, 2014).

According to recent reports published by the Centre for Competition, Regulation and Economic Development (CCRED) of the University of Johannesburg, some of these trends are becoming particularly evident for products and technologies belonging to the metal-machinery value chain, which is one of the most important clusters of manufacturing sectors within the South African economy in terms of contribution to domestic output, exports and employment (Fessehaie, 2015; Bell et al., 2017; Rustomjee et al., 2018). Increasing Chinese exports have intensified the cost-pressure on South African producers both in domestic and foreign markets, especially in the upstream iron and steel sector, and in certain products within the general-purpose equipment industry such as valves and pumps (Van der Merwe and Kleynhans, 2017; Zalk, 2017; Bell et al., 2017; Rustomjee et al., 2018). However, there is some evidence that even more advanced and technology-intensive products in downstream segments of the chain have been negatively affected. Although South African producers of specialised industrial machines have to some extent benefitted from the increased availability of cheaper inputs shipped from China, they are also increasingly facing both direct and indirect competition from Chinese traders and manufacturers, in domestic and foreign markets respectively (Fessehaie, 2015). In this regard, two major catalysts for the expansion of Chinese machinery exports to third markets have been their increasing participation and upgrading along GVCs led by multinationals from advanced economies (Bamber et al., 2016; Fessehaie, 2015), and the internationalisation of their lead Chinese customers, including the many mining companies and construction contractors investing abroad, particularly in the African continent (Tull, 2006; Zeng and Williamson, 2007; Ferreira, 2009; Fessehaie 2012a and 2012b).

Despite these concerns, so far only a limited number of studies have attempted to analyse the different impacts of the rise of China's export and production capacity on South Africa. From the most recent research project conducted on this specific issue, three articles have been published: the first one on the direct effects of increased Chinese imports on South African domestic prices, manufacturing output and employment (Edwards and Jenkins, 2015) and the other two on the indirect effects of increased Chinese exports to other sub-Saharan African countries on South African manufacturing exports (Edwards and Jenkins, 2014; Jenkins and Edwards, 2015). They all make use of aggregate industry- and product-level data, without exploring in detail the heterogeneous dynamics at the firm and sub-sectoral level, triggered by increased Chinese exports and production capacity. A number of sectoral case studies have been published on this specific topic, but they have exclusively covered low capital- and technology-intensive industries, such as textiles and clothing (Morris and Ehinorn, 2008; Bonga-Bonga and Biyase, 2019). The empirical evidence collected in this thesis tries to fill these knowledge gaps in two ways: first, by analysing the heterogeneous effects at the level of the firms (Chapters 3 and 5) and sub-sectors (Chapters 4 and 5) produced by China's increased export and production capacity; and, second, by focusing on the specific dynamics characterising relatively more technology-intensive industries (Chapters 4 and 5). The analysis is restricted to the performance of the formal economy for two main reasons. On the one side, data at the firm- and product-level for informal economic activities are not available and/or easily accessible for South Africa. On the other side, the contribution of the informal economy to total employment in the manufacturing sector remains relatively limited, especially in more technology-intensive industries.[6]

[6] The South African Quarterly Labour Force Survey (Statistics South Africa, 2021) found that between 2008 and 2019, on average, around 2.5 million people were working in the informal (non-agricultural) South

1.3 Research questions, hypotheses and methods

Against the background of the discussion in Section 1.1, the main objective of this thesis is to shed new light on the effects of the dramatic increase in China's export and production capacity on the industrial development dynamics of South Africa. The empirical analysis is restricted to the post-apartheid period, when China's global expansion accelerated, and it focuses on the manufacturing sector. This manufacturing-oriented view builds on a notion of development stemming from a synthesis of the evolutionary and structuralist theoretical approaches to economics. Many studies within these traditions underline how the manufacturing sector – and within it certain MHT industries in particular – constitutes the most powerful engine of aggregate growth, diversification, skills creation and social modernisation available to the developing world, due to its superior potential for innovativeness, learning by doing, externalities and interdependences with the rest of the economy (Hirschman, 1958; Kaldor, 1966 and 1967; Dosi, 1988; Lall, 1992; Andreoni and Gregory, 2013; Szirmai, 2012 and 2013; Andreoni and Chang, 2016). Based on the above considerations, the overarching research question guiding this thesis can be formulated as follows:

RQ. What have been the effects of the rising Chinese export and production capacity on the South African manufacturing sector over the past two and a half decades?

This broad research question is then operationalised in three independent, although interrelated, research venues and studies. Each takes a distinct approach and uses a variety of data sources at different aggregation levels to answer this question from a different angle. The first two studies (Chapters 3 and 4) focus on trade-related aspects of the relation between South Africa and China, while the third study (Chapter 5) looks at competition and complementarities within GVCs at the interface between trade and FDI.

The first study (Chapter 3) builds on the evidence of increasing Chinese import penetration in the South African manufacturing sector and investigates its impact on the growth

African sector. This corresponds to approximately 19% of total non-agricultural employment in the country. The largest percentage of the total informal sector employment is accounted for by trade services (43%), followed by construction and community and social services (15% each). Manufacturing represents a relatively smaller share of total informal sector employment (9%). During the 2008-2019 period, informal employment has accounted for around 12% of total manufacturing employment. Within manufacturing, relatively higher shares of informal employment are found for low-technology industries like food, beverage and tobacco, textile and clothing and furniture. Unfortunately, data on the informal sector's contribution to value added and GDP by industry is not easily accessible for the South African economy.

dynamics of the entire population of manufacturing firms registered in the country. It is guided by the following research question (RQ) and research hypotheses (RH):

RQ1. What have been the effects of the Chinese increasing import penetration on the growth dynamics of South Africa-based manufacturing firms?

RH1.1 Increasing Chinese import penetration might affect the growth dynamics of South Africa-based manufacturing firms both directly and indirectly (i.e., through imports in upstream and downstream segments of the domestic value chain.

RH1.2 Within sectors, firms that invest more intensively in the accumulation of certain productive and technological capabilities might be relatively more resilient to Chinese import penetration and/or in a better position to benefit from the increased availability of cheaper inputs.

To answer this question and generate new evidence on these systemic and heterogeneous dynamics, I have conducted an econometric analysis on a dataset combining secondary quantitative data at the firm level and product level, and input-output indicators.

The second study (Chapter 4) builds on the evidence of increasing Chinese exports of MHT manufacturing products and explores the impact on South African exports to third markets in the same product categories. It aims to answer the following research question and it is guided by two research hypotheses:

RQ2. What have been the effects of the rising global exports from China in MHT manufacturing products on the South Africa's exports to third markets, in the same product categories?

RH2.1 Chinese global exports of MHT manufacturing products might be substitutes for or complements to South African exports to third markets. In the first case, they would displace South African exports, in the second case they would boost them. A third possibility is that China's and South Africa's exports carve out for themselves very different segments of the market, and are thus fundamentally unrelated.

RH2.2 A certain degree of heterogeneity in the effect is expected across different sub-sectors, sub-groups of destination countries and sub-periods of times.

To answer this question an econometric analysis using secondary quantitative data on trade flows at the product level has been carried out.

Finally, by narrowing down the specific set of MHT industries considered, the third study (Chapter 5) looks at the effects of the increasing involvement and upgrading of China within the mining equipment GVC on South African mining equipment producers. This downstream segment of the metal-machinery value chain has been chosen for two reasons. First, it represents the most relevant and technologically advanced sector of the South African special purpose machinery industry (Kaplan, 2012; Lydall, 2009; Walker and Minnitt, 2006). Second, there is evidence that Chinese companies are becoming increasingly competitive within it and are gradually catching up with the industry leaders (Fessehaie, 2015; Bamber et al., 2016). The analysis is developed around the following research question and research hypotheses:

RQ3. What have been the effects of the increasing involvement and upgrading of China in the mining equipment GVC for South African mining equipment producers?

RH3.1 The increasing Chinese involvement and upgrading along the mining equipment GVC might be driven by, and strongly interrelated with, other key restructuring dynamics taking place within this sectoral GVC.

RH3.2 Such restructuring dynamics, in turn, might have fundamentally reshaped the value chain's structure, its power configuration and competition dynamics at the global, regional and local level.

RH3.3 In light of the changing competitive landscape within the industry, the evolving mix of the upgrading strategies of the South African mining equipment producers, as well as their potential for value capture, is likely to be shaped by different types of internal capabilities and the external support system.

Since these aspects are harder to capture by means of secondary quantitative data and statistical and econometric methods, I have adopted a mixed methods case study, combining quantitative and qualitative data from (own) primary and secondary sources.

1.4 Contribution and originality

The contributions of this thesis are primarily of an empirical nature. The main ambition of this work is, indeed, to contribute to a deeper understanding of the global phenomenon under analysis here by means of producing novel and meaningful empirical evidence, although circumscribed to a particular country context. Furthermore, while no general theory is advanced in this thesis, to some extent, the studies in Chapters 3 to 5 also contribute to the existing literature on the theoretical level. Finally, the methodological approach adopted in the present work also adds to its originality.

On the empirical side, this thesis sheds new light on the trade- and GVC-related effects of China's increasing export and production capacity on the South African manufacturing sector. It focuses on different units of analysis at various levels of aggregation (i.e., firms, sectors, sectoral value chains).

In particular, Chapter 3 provides the first micro-econometric evidence of the impact of increasing Chinese import penetration on the growth dynamics of South Africa-based manufacturing firms. The empirical analysis focuses on the competitive impact of import penetration on those South African firms whose output closely competes with Chinese imports, as well as on the competitive and complementary impacts of Chinese import penetration spreading from one South African firm to another through input-output linkages along domestic value chains. The empirical analysis also takes into account firms' heterogeneity, within sectors, in terms of their investment intensity in the development and accumulation of technology and productive capabilities.

Chapter 4 analyses whether and to what extent the rise of China's exports in MHT manufacturing products has displaced or complemented South African exports to third markets in the same product categories. It extends and complements the only available econometric study on this issue, published by Edwards and Jenkins (2014), by focusing specifically on the exports of MHT products at a very detailed level of disaggregation, and by looking at how this displacement or complementary effect varies according to the specific sub-sector, sub-period and destination market under consideration.

The sectoral case study in Chapter 5 identifies the rise of China as one of the main factors behind the ongoing marginalisation of South Africa as a strategic location for the production and innovation of mining-related equipment. It sheds new light on the drivers of the increasing and evolving Chinese involvement in the mining equipment GVC, its different forms and its trade- and FDI-related effects, either direct or indirect, complementary or competitive. This chapter also identifies the evolving mix of the upgrading strategies of the South African mining equipment producers, as well as the internal and external factors hindering their potential for value capture along the chain.

Overall, this new evidence significantly contributes to the debate about whether and how recent globalisation, particularly the rise of China, has shifted the goal posts for a G20 middle-income country like South Africa, intensifying the challenges it faces and increasing the urgency for strengthening domestic innovation capabilities in certain MHT manufacturing sectors.

On the theoretical side, Chapters 3 and 4 enrich standard mainstream analyses of the impact of Chinese competition with key elements of evolutionary and structuralist economics. These include sectoral heterogeneity based on the special properties of certain relatively more technology-intensive activities; firm heterogeneity based on their capabilities; and the complex interactions of the system's components through linkage effects. Chapter 5 integrates theoretical insights from existing GVC approaches, the technology capability framework, and the international business and general management literature to develop a novel GVC interpretative framework. In particular, this analytical GVC framework is 'augmented' by recent advances in research on the changing organisational structures characterising global industries and insights acknowledging the importance of capabilities complementary to core technological and productive ones to capture value from upgrading along GVCs. These theoretical insights provide additional interpretative guidelines for analysing how a small group of TFSs from advanced economies and emerging Chinese players have been able to exercise different forms of bargaining and demonstrative power along the mining equipment GVCs. It also enables understanding of how they have been able to raise the bar for other OMEs producing mining equipment, especially for those in developing countries, by establishing higher de facto standards for operating the chain.[7]

Finally, on the methodological side, the research approach embraced in this thesis also contributes significantly to its originality. In fact, this thesis adopts an original multi-methods research approach, combining two econometric studies and a mixed methods case study. Such a research strategy, and in particular the use of mixed methods case studies, with a significant qualitative component, is still extremely limited in mainstream economics, given its closed system and positives-deductive ontological position. The research strategy adopted in this work has proved particularly effective in shedding new light on different aspects of the multifaceted and complex phenomenon under analysis here. On the one hand, econometric models and large available quantitative datasets have

[7] Mining OEMs are firms that design and manufacture mining components and equipment. In many cases, they also provide after-sales support for their products. With the expression "TFSs", in this research work, I indicate a small group of multinational mining OEMs from advanced countries which have become increasingly influential at the global level within the mining industry. For further details see Chapter 5.

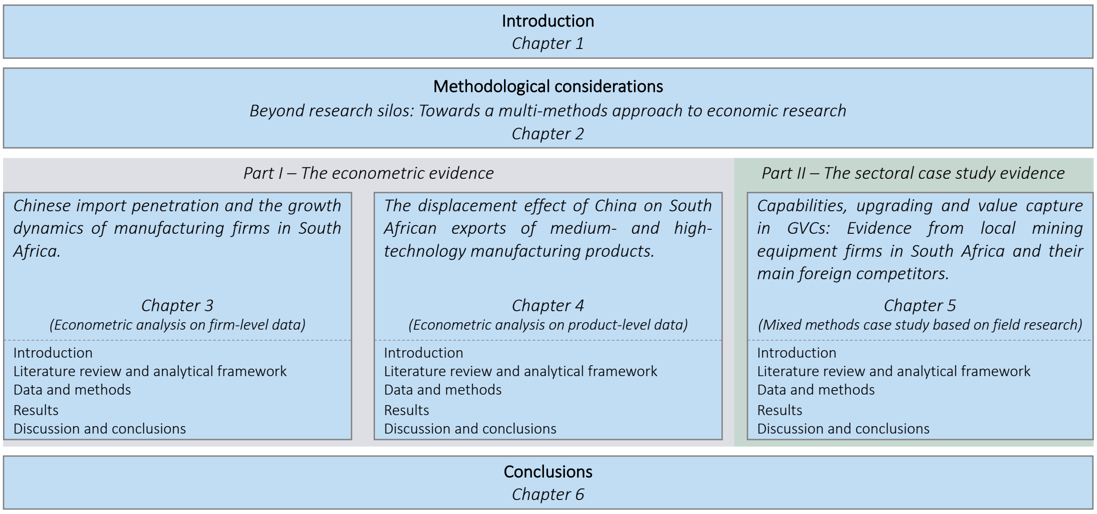
been fundamental for testing a number of research hypotheses in Chapters 3 and 4. On the other hand, the mixed methods case study approach adopted in Chapter 5 has allowed the empirical findings of the previous chapters to be contextualised and complemented, thus overcoming their data limitations and enabling distinct and complex combinations of causes to be investigated. A detailed discussion of the research approach characterising this work, and its methodological underpinnings, is conducted in Chapter 2.

1.5 Outline and summary of the thesis

The rest of this thesis is divided into five chapters. The main body of the thesis consists of three independent – although highly interrelated – chapters (Chapters 3 to 5), organised in two parts. Each chapter takes a distinct approach and uses different data sources to explore different aspects of the object of research, i.e., the role of China's increasing production and export capacity for the dynamics of manufacturing development in South Africa over the past two and a half decades. Specifically, Chapters 3, 4 and 5 answer research questions introduced above (i.e., RQ1, RQ2 and RQ3, respectively).

Part I consists of two econometric studies (Chapters 3 and 4), employing existing quantitative secondary data, while Part II is made up of a mixed methods case study, combining quantitative and qualitative data from (own) primary and secondary sources (Chapter 5). These chapters follow a similar structure, comprising an introduction, a literature review and an analytical framework, a description of the data and the methods used, a presentation and a critical assessment of the empirical results, a discussion of the main policy implications and a concluding remarks section. They have been designed to shed new light on different aspects of the main research topic of this thesis and, thus, to present a comprehensive picture of it. Chapters 3 to 5 are preceded by a chapter presenting some overarching methodological considerations (Chapter 2) and followed by concluding remarks (Chapter 6). Figure 1.1 outlines graphically the structure of the thesis.

Figure 1.1. A schematic representation of the thesis's structure.



Chapter 2 argues for the adoption of the multi-methods research approach used in this thesis, discussing its benefits when conducting empirical research on international trade and industrial development in an emerging country context like South Africa. To this purpose, first it shows that such an approach is consistent with the methodological positions of the key streams of the non-mainstream (or heterodox) economic literature used to frame the empirical research in Chapters 3 to 5, namely evolutionary and structuralist economics, and critical approaches to global value chain analysis. Second, it explains why a carefully designed combination of econometric analyses based on quantitative secondary data (Chapters 3 and 4) and a mixed methods case study based on quantitative and qualitative data from (own) primary and secondary sources (Chapter 5) has proved particularly effective in shedding new light on different aspects of the main research topic of this thesis.

On the one hand, econometric models and large available quantitative datasets have been fundamental to test a number of hypotheses with respect to the impact over time of Chinese import penetration on the growth dynamics of South Africa-based manufacturing firms (Chapter 3) and on the South African exports of specific sets of products to third countries (Chapter 4). On the other hand, the mixed methods case study approach adopted in Chapter 5 has proven reliable for investigating the relationship between foreign competition stemming directly or indirectly from Chinese and non-Chinese companies, firms' capabilities, upgrading and value capture trajectories in a specific sectoral value chain in South Africa. In particular, the use of a case study approach with a substantial qualitative component has allowed the empirical findings of the previous chapters to be contextualised and complemented. Field data has been particularly useful in overcoming a number of data limitations characterising Chapter 3 and 4, and in investigating distinct and complex combinations of causes, which may be interrelated and may reinforce each other. The chapter concludes by discussing a number of practical barriers to the greater integration of quantitative and qualitative methods within the economic discipline.

Chapter 3[8] starts to shed new light on the direct competitive and complementary impacts of increasing Chinese imports on the South African domestic production system. Specifically, the chapter examines the heterogeneous and systemic impacts of Chinese import penetration on the entire population of South Africa-based manufacturing firms in the aftermath of the global financial crisis (GFC). Using firm-level tax administrative data from 2010 to 2017[9] and employing an instrumental variable approach, I study the extent to which Chinese import penetration has affected the growth performances of manufacturing firms registered in South Africa.

In doing that, I enrich standard mainstream applied analyses of the impact of Chinese competition with key elements of evolutionary and structuralist economics. First, I disentangle the impacts of direct and indirect Chinese import penetration along domestic value chains.[10] I consider the impact of direct Chinese import penetration on South African firms whose output directly competes with such imports, as well as the impact of Chinese import penetration spreading from one South African firm to another through input-output linkages along domestic value chains (i.e., indirect Chinese import penetration). The importance of disentangling the impact of the indirect import penetration is inspired by the structuralist multi-sectoral models and structural development economics literature emphasising the importance of these intersectoral linkages in countries' economic

[8] An early version of this chapter has been published in the UNU-WIDER Working Paper Series with the title 'Dancing with Dragons: Chinese import penetration and the performances of manufacturing firms in South Africa', as part of the SA-TIED Research Program (Torreggiani and Andreoni, 2019). The paper and a related research brief are available online at https://www.wider.unu.edu/publication/dancing-dragons and https://www.wider.unu.edu/publication/dancing-dragons-0.

[9] This firm-level dataset only covers the 2008-2017 period. However, the years 2008 and 2009 have been excluded from the analysis because of their many missing values.

[10] It is important not to confuse the direct and indirect Chinese import penetration (or competition) introduced in Chapter 3 with the direct and indirect effects of the rise of China in global and South-South trade and GVCs as defined in Section 1.2.2. *Direct* import competition refers to the import penetration faced by the sub-sector in which the unit of observation (i.e., firm), whose output directly compete with Chinese imports, operates. *Indirect* import competition is defined as the weighted average of the import penetration faced by all the other industries that purchase inputs from (or sell them to) the sub-sector in which the unit of observation (i.e., firm) operates. The latter, in particular, has been extremely useful in quantifying the impact on firms of Chinese import penetration spreading through input-output linkages along domestic value chains (this effect can be, in turn, complementary given the increased availability of cheaper inputs in upstream sectors, for example). Further details of this can be found in Chapter 3.

structures. It also allows for the exploration of the presence of a significant direct complementary effect, as defined in Section 1.2.2, driven by increased imports of cheaper inputs from China in upstream segments of domestic value chains. Second, I analyse whether firms investing more intensively in capabilities development – notably in process and product innovation, and in skills development – are better able to cope with such competitive pressure and to benefit from the increased availability of cheaper inputs. The construction of these variables and their inclusion in the analysis allows for the testing of some of the hypotheses put forward by evolutionary capability theories of the firm, which suggest how firms' reactions to competitive pressure are highly heterogeneous as they critically depend on their different capabilities.

The empirical results indicate that rising exposure to Chinese imports – not only directly, but also in downstream segments of the domestic value chain – leads to slower sales and employment growth for the entire sample of surviving firms, and to a higher probability of shutdown for firms not undertaking significant investments in capabilities development. However, I also find that, within industries, firms investing relatively more intensively in skills development, and product and process innovation, are more likely to survive and grow, despite rising import competition. Finally, the increased availability of cheaper inputs from China in upstream segments of the domestic value chain does not appear to have any significant impact on the growth dynamics of firms downstream.

Chapter 3 does not directly address the question of whether increasing Chinese exports have also indirectly affected South African manufacturing exports to third markets (i.e., indirect competitive or complementary effects as described in Section 1.1.2). ***Chapter 4*** deals precisely with this aspect, analysing the potential displacement or complementary effect on South African exports in selected manufacturing sub-sectors arising from growing Chinese exports from international markets in the same product categories. Specifically, I employ gravity modelling and an instrumental variable strategy to investigate whether and to what extent the rise of China's exports in MHT manufacturing products has displaced or complemented South African exports to third markets in the same product categories, over the 1995-2018 period.

The case for focusing on such sectors is supported by a long-established tradition of evolutionary and structuralist thought, which argues that specialising in the production and export of relatively more technology-intensive activities matters for the future growth prospects of developing countries. Interesting dimensions of heterogeneity are captured by testing for the presence of a Chinese crowding-out effect on South African exports of MHT products at different levels of disaggregation: (*i*) for the full sample of products, destinations and years; (*ii*) for each sub-sector within the MHT group of manufacturing products; (*iii*) for different groups of destination markets; (*iv*) for different sub-periods; and (*v*) by taking into account the role of Hong Kong as a major conduit for mainland China's world exports.

The empirical results show that, overall, Chinese exports of MHT manufacturing products have displaced competing South African exports in third countries over the 1995-2018 period. Nonetheless, the results display a certain degree of heterogeneity. China's crowding-out effect on South African exports has been more severe in specific sub-sectors (e.g., iron and steel, household appliances, metalworking machinery and machine tools, chemicals and electrical machinery) and destination markets (e.g., non-OECD countries, African and sub-Saharan African economies in particular). Furthermore, my estimates reveal that this displacement effect is larger when exports from Hong Kong are combined with those from mainland China and when taking into account only the sub-period following the GFC.

Finally, the chapter identifies the mining equipment sector as one of the medium-technology industries that has followed an interesting trajectory over the past two decades and requires further investigation. In fact, although during the 1995-2006 period South Africa-based mining equipment producers proved to be sufficiently competitive in third markets relative to Chinese exports, the trend does appear to have turned negative more recently, since 2010, in the aftermath of the GFC and towards the end of the commodity boom.

Building on this preliminary evidence, ***Chapter 5*** explores the main reasons behind the ongoing marginalisation of South Africa as a strategic location for the production and innovation of mining-related equipment, despite the strong core technological and production-related capabilities of its domestic supplier base. By narrowing down the specific cluster of MHT sectors considered, this chapter is able to broaden the scope of the analysis to look at key aspects of the rising Chinese influence that are not necessarily accessible through the study of secondary quantitative data and by means of statistical and econometric methods. These include the drivers of the increasing and evolving Chinese involvement in the mining equipment GVC, its different forms and its trade- and FDI-related effects, either direct or indirect, complementary or competitive.

Specifically, in this chapter, the increasing Chinese involvement in global and regional mining equipment value chains is analysed in combination with other interrelated global restructuring dynamics (i.e., the increasing market dominance by a few TFSs), and the specific internal and external constraints affecting the performance of domestic manufacturers. This analysis builds on recent advances within and beyond the GVC literature. On the one hand, it elaborates on academic contributions focusing on changing organisations structures and the evolving competitive landscape for global industries. On the other hand, it expands upon micro-level studies on technological capability building in emerging economies' firms within the context of globalised industries. The empirical evidence is based on 49 in-depth, semi-structured interviews and two focus groups conducted with industry representatives and experts in South Africa during 2019.

A first set of results emphasises the role of dominant incumbent TFSs and powerful emerging Chinese manufacturers in producing changes in the power configuration and competition dynamic along the value chain, and in raising the bar for suppliers in developing countries to enter, upgrade and capture value within it. A second series of findings underlines that, within this evolving competitive scenario, it is of paramount importance for South African suppliers to develop and strengthen a set of capabilities complementary to the core technological and productive ones, yet specific to the mining equipment GVC, in order to maximise value capture and enter into fruitful bargaining processes with the chain's leaders.

The chapter also discusses the main implications of these results for both policy and theory. With respect to the former, I analyse a number of sector-specific policy interventions that are crucial for strengthening key firms' capabilities and, thus, the competitive position of South African manufacturers, especially in regional and global markets. As far as the latter is concerned, I suggest that the academic debate on upgrading along GVCs, within the context of the rapidly changing nature of competition in global industries, should include, to a greater degree, considerations other than those relating exclusively to the development and accumulation of core technology- and production-related capabilities. In that respect, the chapter argues in favour of a greater integration between existing GVC approaches, the technology capability framework, and the international business and general management literature.

Chapter 6 concludes, summarising the main findings and contributions of this thesis and drawing the relevant implications for theory development, methodology and South

Africa's industrialisation strategies. It also reflects on avenues for further research, particularly investigating more closely the potential effects on the South African industrialisation trajectories of a number of emerging trade-related global trends, which arose during the research process for this thesis, between late 2017 and late 2020. These include the trade war between the United States and China in 2018-2019, the outbreak of the COVID-19 pandemic and the 'dual circulation' strategy in economic policy recently launched by the Chinese government.

Chapter 2

Beyond research silos: Towards a multi-methods approach to economic research

2.1 Introduction

Methodology constitutes a particularly important aspect of every research project. Nevertheless, an explicit and open discussion on the methodological foundation of the analysis is only rarely raised within the economic discipline, especially in the dominant current mainstream or neoclassical project (Lawson, 1997).[11] A notable exception, over the past few years, has been the resumption of the methodological debate around the use of randomised control trials (RTCs) in development economics (Deaton and Cartwright, 2018; Stevano, 2020). However, the mainstream literature has remained relatively silent in terms of methodological discussions in research areas where RCTs are applied to a lesser degree.

The aim of this chapter is to elaborate on the research approach embraced in this work and its methodological underpinnings, which are elements that contribute significantly to its originality. This thesis develops along two main lines of inquiry, organised in as many parts. The first focuses on the impact over time of Chinese import competition on the growth dynamics of South Africa-based manufacturing firms (Chapter 3) and on the South African exports of MHT products to third countries (Chapter 4). This part consists of two econometric studies, employing existing quantitative secondary data – both publicly and non-publicly available. The second part of the thesis investigates the relationship between foreign competition stemming directly or indirectly from Chinese and non-Chinese companies, and the capabilities, upgrading and value capture trajectories of South African firms along the mining equipment value chain (Chapter 5). This part is made up of a mixed

[11] The term 'methodology' can refer to both an approach's overarching ontological, epistemological and methodological framework and a specific research strategy (Blaikie, 2000; Dow, 2002). In the latter sense it is essentially concerned with the logic of inquiry that shapes how research is conducted, how different methods are combined and implemented, and the sense that is made of their use (Olsen and Morgan, 2005; Grix, 2002; Morgan, 2016). Here the term 'methodology' is used in the former sense, otherwise the expressions 'research strategy' or 'approach' is adopted. 'Methods' refers to the procedures and techniques used for collecting, transforming and processing different types of data.

methods case study, combining quantitative and qualitative data from (own) primary and secondary sources.

With respect to the mode of research it engages in, this thesis – and in particular Part II – integrates information, data, tools and perspectives from different disciplines outside the economic domain, such as international business, innovation, engineering and operation management studies. This chapter argues for the adoption of this particular multi-methods and interdisciplinary research approach and underlines its benefits when conducting empirical research on international trade and industrial development in an emerging country context like South Africa.

To this purpose, the next section (Section 2.2) makes some observations on the methodological background of this thesis. It briefly elaborates on the ontological and epistemological stances of the three strands of the non-mainstream economic literature used to guide the empirical research in Chapters 3 to 5, namely evolutionary and structuralist economics, and critical approaches to global value chain analysis. In fact, Chapters 3 and 4 incorporate key aspects of evolutionary and structuralist economics to enrich more standard analyses of the impact of Chinese competition, i.e., as they are generally carried out within the context of current mainstream economics. In Chapter 5, critical approaches to global value chain analysis, as well as evolutionary, resource-based and capability theories of the firm, are used to frame the empirical analysis. Based on this examination of the methodological underpinnings of these strands of the literature, Section 2 argues in favour of the use of the multi-methods and interdisciplinary approach adopted in this thesis, combining two econometric analyses (Chapters 3 and 4) and a mixed methods case study (Chapter 5). In fact, it is stressed that this particular approach is consistent with the methodological positions of the key streams of the literature adopted here. In particular, on the one hand, the extensive use of statistical and econometric analysis is in line with the practice of many evolutionary and structuralist applied studies on international trade and industrial development, although they put much more emphasis on the heterogeneous characteristics of firms and sectors than is frequently found in mainstream applied economics. On the other hand, the use of mixed methods case studies, based on extensive field research and with a substantial qualitative component, is close to the spirit of the empirical work of many GVC scholars, some structuralist development economists and some authors conducting research on innovation systems and firms' capabilities.

Section 2.3 reviews the econometric methods and available quantitative data employed for answering the research questions in Chapter 3 and Chapter 4. It discusses how the econometric analysis has been conducted, and its results interpreted, in line with the methodological considerations of the previous section. It also outlines the related strengths and limitations of such methods.[12] Section 2.4 explains how in Chapter 5 field research and a mixed methods case study approach may help to overcome at least some of these limitations, contextualising and complementing the empirical findings from quantitative studies employing secondary data and econometric techniques. Section 2.5 concludes, arguing in favour of drawing from other fields of knowledge and using multiple methods, both qualitative and quantitative, when conducting economic research in general, despite the practical barriers to their greater integration within the economic discipline.

2.2 Multi-methods and interdisciplinary research in non-mainstream economics

This thesis does not aim to contribute directly to the debates about methodology and epistemology in economics. Nevertheless, some considerations are deemed particularly important with respect to the adherence of this work to the methodology generally adopted in many non-mainstream economics traditions or projects, and more specifically in evolutionary and structuralist economics, as well as in critical approaches to global value chain analysis.

2.2.1 Knowledge building within the context of an open system ontology

It has been argued that the essential difference between current mainstream economics (i.e., neoclassical) and non-mainstream economics traditions lies in the fact that the latter adheres to an open system ontological stance (Lawson, 1997; Dow, 2000). This view is rooted in a critical realist interpretation of the social world.[13] Therefore, the boundaries of

[12] These strengths and limitations are obviously examined further in the methodological and concluding sections of each single chapter throughout the thesis.

[13] Critical realism is one of the philosophical approaches to the sciences which maintains that the social world is an open system (Bhaskar, 1978, 1979 and 1986). It has been explored in economics, initially by Lawson (1989, 1997, 1998 and 2001) and Fleetwood (1999). Within the economic domain, the critical realist project underlines the main limitations of neoclassical economics, and, at the same time, provides a philosophical and methodological foundation for a broad range of alternative approaches. In particular, critical realism has been discussed as a possible basis for neo-Marxist (Nielsen, 2002), Post Keynesian (Arestis, 1996; Lee, 2002; Dunn, 2004) and evolutionary economics (Foss, 1994; Northover, 1999; Castellacci, 2006). Conversely, in-depth analyses on whether or not structuralist economics as well as GVC and global production network (GPN) approaches can be interpreted under the lenses of critical realism are less frequent and structured (Baghiratan et al., 2004; Coe and Yeung, 2015).

the system are affected and determined by social reality, which is intrinsically dynamic and only rarely confronts us with "closures of causal sequence" (Lawson, 2006a and 2015), i.e., of the sort pursued in current mainstream economics.

On an ontological level, many non-mainstream economics traditions maintain that reality is structured, interconnected, open, differentiated, dynamic and persistently out of equilibrium (Dosi et al., 1995; Lawson 2006; Pasinetti 2007). Its deep structures, processes and causal mechanisms are not directly observable and can be inferred – though not always (Lawson, 1997; Kaltebrunner, 2011) – from observable surface events (King, 2015). On an epistemological level, given the hidden and constantly changing nature of reality's deep structures and causal mechanisms, the adoption of an open system approach also implies that not all relevant variables and relationships between such variables are knowable. Thus, they are not representable in a single formal mathematical model, and the formulation of general laws and time- and context-free conclusions is not possible (Dow, 2000; Downward and Mearman 2002). These ontological and epistemological stances obviously mark a distinction with the methodological reductionism characterising modern neoclassical economics, where reality is theorised as a closed, self-contained, static, atomistic and deterministic system, and thus it can be investigated by means of mathematical modelling and deductivist methods (Lawson, 2006a; Pasinetti 2007).

According to a critical realist view, within the context of an open system ontology, knowledge can be built up through a 'retroduction' process,[14] by moving from stylised facts and partial event regularities (or 'demi-reg'), identified using a range of different research methods (Lawson, 1997 and 2015; Dow, 2000), to the underlining mechanisms and deep structures which may have generated them (Castellacci, 2006). On the basis of similar considerations, many different non-mainstream economics traditions provide a solid basis for combining different research methods, both qualitative and quantitative, based on the nature of the specific research question (Downward and Mearman, 2007; Castellacci, 2006). This case for using and combining multiple methods is supported by both the open system ontological stance shared by critical realism and many different non-mainstream

[14] Retroduction constitutes the logic of inference proposed by critical realists and can be seen as an alternative to other research strategies such as deduction and induction. According to critical realists, the researcher can uncover the mechanisms and the deeper structures of the reality by formulating hypothesis about them which are then investigated and updated by means of observed surface events and empirical evidence in an iterative and cumulative fashion (Lawson, 1994 and 1997).

economics traditions, which sees reality as open, structured and permanently changing, and by their epistemological positions, based on the fallibility of knowledge.

The following sub-section elaborates on the methodology and the methods adopted by the three strands of the non-mainstream (or so-called heterodox) economic literature used in this thesis to guide the empirical research in Chapters 3 to 5, namely evolutionary and structuralist economics, as well as critical approaches to global value chain analysis. It is argued that the use of the multi-methods and interdisciplinary approach adopted in this work, combining two econometric analyses (Chapters 3 and 4) and a mixed methods case study (Chapter 5), is consistent with the methodological positions of these three streams of the literature and is well suited to addressing the specific research questions contained in each chapter and introduced in Section 1.3 of Chapter 1.

2.2.2 Evolutionary economics, structuralist economics and global value chain analysis: some methodological considerations

a. Evolutionary economics

Although a variety of different theories, approaches, models and arguments characterise evolutionary economics, they all share to some extent a number of principle characteristics, general concepts and ontological assumptions about the social world (Nelson and Winter, 1982; Dosi, 1991; Dosi et al., 1995). Among these is the shared interest in matters like economic transformation and change, novelty and innovation. Evolutionary economists do not take institutions, technology or, more generally, complex phenomena, as given, but they study how they emerge from processes of self-organisation and competitive selection, and how they develop over time (Hodgson, 2011).

The evolutionary ontology characterises the economic world as open, complex, differentiated, structured, systemic, dynamic, radically uncertain and persistently out of equilibrium (Dosi, 1991; Dosi and Nelson, 1994; Dosi et al., 1995; Foss, 1994; Hodgson, 1995). The recognition of the openness of the socio-economic systems, and its constantly changing nature, also implies the potentiality for novelty and innovation, and the possibility of emergent properties (Hodgson, 1995 and 2011). These features, in turn, suggest a strong, although implicit, connection between a number of strands in the literature within evolutionary economics and the critical realist ontology (Foss, 1994; Castellacci, 2006).[15] Both approaches are similar in their focus on the multilevel feedbacks and interactions between the various components of the system, as well as on the inherent uncertainty in systemic structures given their stratification, complexity, open character and the persistent heterogeneity of the agents (Castellacci, 2006; Vega and Chiasson, 2019).

With regard to the epistemological position and the specific research strategy, the compatibility of critical realism and many research traditions within evolutionary economics (i.e., those reported in footnote 15), is reflected in three interrelated elements. First, given the complex, ever-changing and non-deterministic character of the reality, both evolutionary economists and critical realists acknowledge that causal mechanisms can be investigated, but never formalised in terms of general laws and universal time- and context-free models. Second, interdisciplinarity, at different levels of analysis,[16] is a cross-cutting aspect of many contributions within evolutionary economics and a direct consequence of the open system nature of the evolutionary world. Finally, several research traditions in evolutionary economics relevant to the present thesis make extensive use of appreciative theorising,[17] implicitly adopting a retroductive mode of investigation that in turn constitutes the link between formal theorisation and applied work, and between qualitative and quantitative research (Castellacci, 2006).[18]

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[15] With the expression 'evolutionary economics' Castellacci (2006) refers to a number of closely related research traditions. These comprise the original work by Nelson and Winter (1982), the neo-Schumpeterian theory of long waves (Freeman, 1983; Dosi, 1982; Perez, 1983), the technology-gap theory (Fagerberg, 1987; Dosi et al., 1990; Dosi et al., 2015a), the history-friendly models of industry evolution (Malerba et al., 1999) and the system of innovation framework (Freeman, 1987; Lundvall, 1992), applied to sectors (Malerba, 2002), regions (Asheim and Gertler, 2005) and national economies as a whole (Edquist, 2005). Here, I extend this definition, also taking into account those contributions of evolutionary inspiration focusing on corporate characteristics, capabilities, performances and their dynamics (Dosi et al., 2010), especially in developing countries (Lall, 1992 and 1999), which are extremely relevant to the present work. As in Castellacci (2006), I exclude from this categorisation agent-based modelling approaches, which are not of particular significance for this thesis.

[16] In fact, at the microeconomic level evolutionary economics has built up analytical explanations in close connection with cognitive psychology, business and organisation studies, while at the macroeconomic level it strongly relies on insights from economic sociology, political science and history (Castellacci, 2006; Dosi, 1991).

[17] Nelson and Winter (1982) underline the difference between appreciative and formal theory. The concept of appreciative theorising tends to stay close to the empirical substance of the subject matter. It provides both guidance and interpretation, and is mostly articulated verbally (Nelson, 1994, p. 292). Formal theory is expressed in a more abstract form, often as a mathematical model.

[18] I am obviously well aware that, within the evolutionary economics tradition, there are a number of approaches, which make extensive use of formal analysis and mathematical techniques, as in agent-based models (Fagiolo and Dosi, 2003; Dosi et al., 2010; Safarzyńska and van den Bergh, 2010; Fagiolo et al., 2020) – although these are mainly used to develop illustrative simulations, rather than to derive general time- and context-free laws and analytic solutions (Hodgson, 2011). However, as already stressed in footnote 15, here I do not refer to the whole spectrum of contributions within the evolutionary economics research tradition,

Specifically, qualitative and mixed methods case studies are typical of contributions within the system of innovation framework. Other streams (i.e., technology-gap theories, evolutionary theories of economic growth and industrial dynamics, technological capability theories of the firm) also make extensive use of quantitative methods. Thus, while both evolutionary economics and critical realism reject the methodological reductionism, and the positivist and empiricist approach of neoclassical economics, a number of strands within evolutionary economics adopt a favourable position with respect to the use of econometrics in the social sciences (Castellacci, 2006; Hodgson, 1995 and 2011). However, in evolutionary economics, unlike in mainstream applied works, econometric and statistical techniques are mainly employed to uncover the emergence of irreducible heterogeneity across meso- and micro-entities (i.e., sectors, firms and households) by means of a systematic study of their distinct characteristics, capabilities, performances (Lall, 1999; Bhadury and Ray, 2004; Ito and Lechevalier, 2010; Molina-Domene and Pietrobelli, 2012) and their distributional properties (Dosi, 2007; Fagiolo et al., 2010; Bottazzi and Grazzi, 2014; Dosi et al., 2015a).

b. Structuralist economics

The rejection of a positivist and empiricist approach to economics is also typical of the realist and holistic perspective adopted by many structuralist economists (Jameson, 1986; Wilber and Francis, 1986; Palma, 1987; Missio et al., 2015). At the ontological level, structuralist economists share with evolutionary economists (and, admittedly, also with critical realists) the focus on the complex, structured and permanently changing character of reality as a process of evolutionary change, driven by the dynamic interactions between the various components of the system and the system as a whole (Jameson, 1986; Palma, 1987; Baghiratan et al., 2004; Sanchez-Ancochea, 2007; Blankenburg et al., 2008; Missio et al., 2015).

In economics, at least two structuralist traditions can be distinguished: I refer to the first one as the 'structural development economics' stream and to the second one as the 'structural economic dynamics approach. On the one hand, contributions within the structural development economics stream emphasise the relevance of 'structures' in affecting the economic trajectories of less developed countries, the distinct structural

but only to those of particular significance for the present research work, which, in turn can be more easily associated with appreciative theorising (Castellacci, 2006).

characteristics of countries at different levels of development, and the need for structural change, through the expansion of those industrial sectors displaying higher productivity. Two distinct traditions can be identified within structural development economics (Sanchez-Ancochea, 2007; Missio et al., 2015; Dutt, 2019): the so-called Anglo-Saxon or European-US structuralism (Rosenstein-Rodan, 1943; Nurkse, 1953; Singer, 1950; Lewis, 1954; Myrdal, 1957; Hirschman, 1958) and the Latin American structuralism (Prebish, 1950), developed under the leadership of the Economic Commission of Latin America and the Caribbean (ECLAC). On the other hand, the structural economic dynamics approach focuses on the study of the continuous and permanent changes in the composition of the basic macroeconomic magnitudes (i.e., gross national product, total employment, total consumption, total investment) of the economic system over time (Pasinetti, 1981 and 1993; Baranzini and Scazzieri, 1990; Araujo and Teixeira, 2003 and 2004; Araujo and Lima, 2007). This approach has a far more general application and, contrary to the structural development economics stream, does not focus on the specific problems of less developed countries. However, despite the substantial differences between these distinct structuralist approaches, the ideas of both are rooted in a view of the industrial world as a "permanently evolving economic system" (Pasinetti, 2012, p. 284) composed of multiple sectors and production activities, linked by complex structural interdependencies operating at different levels of aggregation (Andreoni and Chang, 2019).

At the epistemological level, both the evolutionary and the structuralist approaches can be derived from a realist concept of science, which aims to explain complex, interrelated and dynamic processes rather than predicting specific results (Baghirathan et al., 2004). The explanatory success of the analysis mainly depends on the researcher's ability to understand the deep structures which underpin the observed events (Jameson, 1986). Structuralism employs a mode of inference similar to that of retroduction, which starts with observed phenomena, i.e., Kaldor's (1961) stylised facts, and then works back to a theoretical framework, using a variety of quantitative and qualitative methods (Wilber and Francis, 1986; Baghirathan et al., 2004). For example, quantitative methods of decomposition and formal multi-sectoral models are particularly common within the structural economic dynamics stream (Schilirò, 2012). Latin American structuralism has been found to employ its own structural-historical method combining both statistical and qualitative historical analysis (Missio et al., 2015). There are also cases of authors, for example, Albert Hirschman, who test their hypothesis and themes by using of a variety of different information, including personal observation and interviews, as well as survey data (Wilber and Francis, 1986). In line with evolutionary economists, structuralists argue that economic analysis cannot be limited to the positivist attempt to formulate a general or universal theory (Missio et al., 2015; Wilber and Francis, 1986) that would support a one-size-fits-all policy prescription (Baghirathan et al., 2004). According to them, indeed, both theories and policy prescriptions "refer to an economy at a specific time and place in its historical development" (Baghirathan et al., 2004, p. 320). In other words, this means that any analysis is historically contingent and hardly generalisable (Missio et al., 2015).

c. Critical approaches to GVC and GPN analysis

While acknowledging the fundamental differences between the GVC and the global production networks (GPNs) frameworks (Bair, 2009; Parrilli et al., 2013), in this thesis I consider them as formulations expressing an essentially common perspective for analysing and understanding the global market engagement of firms, regions and nations, the international production systems and the dynamics of contemporary globalisation (Neilson et al., 2014). Explicit methodological reflections on the philosophical foundation of the analysis are fairly rare within the GVC and GPN frameworks (for a notable exception see Coe and Yeung, 2015). However, in the writer's opinion, the emphasis of recent GVC and GPN studies on the complex and dynamic organisational structures and spatial configurations of global industries, as well as on the strategies, capabilities and agency of heterogenous firm- and non-firm actors, fits quite well with an open system ontological orientation. This view is supported by some recent considerations within the GPN literature (Afewerki, 2020). Similarly, from an epistemological point of view, the approach to theory development and empirical analysis of many scholars adopting a GVC or GPN analytical framework is often consistent with a critical realist stance. The main objective of the analysis, indeed, is to uncover the underlining necessary and causal mechanisms (i.e., key agents' capabilities and strategies) shaping empirically observable patterns (i.e., the organisation and configuration of global production systems, as well as their evolutionary dynamics). Context and contingency are seen as key aspects of this approach to theory and empirical enquiry, "because they provide the relevant condition(s) in which these mechanisms can be efficacious" (Coe and Yeung, 2015, p.115).

Interdisciplinarity is another important characteristic of the GVC and GPN research, as that research draws on approaches deployed in economic sociology, economic geography, innovation studies, international political economy, and regional and development studies, as well as international business, general management and supply chain management

(Kano et al., 2020). To shed light on the strategies, capabilities, agency and performance of different firm and non-firm actors, as well as on the organisational and geographical configuration of 'glocal' production systems,[19] GVC and GPN researchers have extensively and successfully conducted mixed methods case studies with a substantial qualitative component (Bair and Gereffi, 2001; Giuliani et al., 2005; Nadvi and Halder, 2005; Whitfield et al., 2020; Coe et al., 2004; Yang, 2009; Yeung, 2007 and 2016, to name just a few). Within this context, case study research using primary qualitative information, often gathered through personal interviews (Yeung, 1995), has been seen as particularly suited to identifying causal relationships and mechanisms through qualitative comparative analysis, pattern-matching and process-tracing (Sayer, 2000; Yeung, 2003; Yin, 2009).

The use of a multi-methods and interdisciplinary approach in this thesis is thus consistent with the methodological positions of the three key streams of the literature guiding the empirical investigation in Chapters 3 to 5.

In line with a retroductive logic, Chapters 3 to 5 start from observed phenomena and formulate hypotheses about different aspects of the object of research, i.e., the effects of China's increasing role in global and intra-developing countries trade and value chain on the dynamics of industrial development in South Africa over the past two and a half decades. Then, empirical evidence is gathered and analysed with the aim of both testing the hypothesised relations (Chapters 3 and 4), and uncovering the deeper structures and mechanisms underlining them (Chapter 5). To this purpose, Chapters 3 and 4 make extensive use of statistical and econometric methods employing secondary quantitative data, in line with many evolutionary and structuralist applied studies on international trade and industrial development. Chapter 5 is based on field research and makes use of a mixed method case study approach combining quantitative and qualitative data from (own) primary and secondary sources, in the spirit of the empirical work of many GVC scholars, some structuralist development economists, and some authors conducting research on innovation systems and firms' capabilities.

2.3 Econometric analyses of secondary quantitative data

[19] These can be defined as local production complexes in a given economy that also constitute nodes of regional and global networks, and whose organisations operate at the 'glocal' interface. The term has been used extensively in the case of Italian districts (Sammarra, 2003; Amighini and Rabellotti, 2006; De Marchi and Grandinetti, 2014).

In line with the practice of many evolutionary applied studies on international trade (Fagerberg, 1994; Lall, 1999; Bhaduri and Ray, 2004; Molina-Domene and Pietrobelli, 2012; Dosi et al., 2015a; Grazzi and Moschella, 2018, to name just a few), this thesis makes extensive use of statistical and econometric analysis. Specifically, different econometric approaches using available quantitative data from a number of different secondary sources have been employed to shed light on the impact over time of Chinese import competition on the growth dynamics of South Africa-based manufacturing firms (Chapter 3) and on the South African exports of MHT products to third countries (Chapter 4).

The analysis conducted in Chapter 3 is based on a database I built combining a unique firm-level tax administrative dataset providing detailed information on the entire population of registered companies in South Africa with data on product-level international trade flows and domestic sectoral input-output linkages. In particular, trade data was provided by the UN Comtrade database, production and input-output data came from Statistics South Africa, while firm-level data from company and employee income tax certificates was obtained from the South African Revenue Service (SARS).[20] Employing panel data micro-econometric techniques, this study explores whether and to what degree Chinese import penetration has affected the growth performances of South Africa-based manufacturing firms in the aftermath of the global financial crisis, from 2010 to 2017.

Chapter 4 employs trade data at 6-digit product level obtained from UN Comtrade, combined with variables provided by other sources, such as the World Development Indicators Database and the gravity database of CEPII.[21] Using gravity modelling techniques, this study investigates whether and to what extent the rise of China's exports in MHT manufacturing products has displaced (or complemented) South African exports to third markets in the same product categories, over the 1995 to 2018 period.

From a methodological point of view, efforts have been made to incorporate in both econometric models some elements specific to the evolutionary-structuralist view of the economic world, namely heterogeneity and complex interactions among system components. In this respect, Chapter 3 has two notable elements of originality and innovativeness. First, new dimensions of firm heterogeneity have been captured by studying whether firms investing more intensively in capabilities development – notably in process and product innovation, and in skills development – are better able to cope with

[20] See the data section in Chapter 3 for further details on this.
[21] See the data section in Chapter 4 for further details on this.

the competitive pressure stemming from China. This allows for testing some of the hypotheses put forward by Schumpeterian, resource-based and capability theories of the firm (Penrose, 1959; Amsden, 1997; Dosi et al., 1990 and 2000; Lall, 1992 and 1999; Teece, 1986; Lin and Chang, 2009), which suggest how firms' reactions to competitive pressure are highly heterogeneous as they critically depend on their different capabilities.

Second, in this econometric model I do take into account the complex networks of buyer-supplier interactions within the domestic economic system. In fact, besides the direct impact of Chinese import competition on South African firms (i.e., import competition in the same product category and sector where the firm itself operates), the model also considers the indirect impact spreading from one South African firm to another through input-output linkages along domestic value chains. The importance of disentangling the indirect impact of import penetration is inspired by the structuralist multi-sectoral models and structural development economics literature emphasising the importance of these intersectoral linkages in countries' economic structures (Hirschman, 1958 and 1997; Chang and Andreoni, 2020).

In the case of Chapter 4, an interesting dimension of heterogeneity is captured by testing for the presence of a Chinese crowding-out effect on South African exports for each sub-sector within the MHT group of manufacturing products. The case for focusing on these sectors is supported by a long-established tradition of evolutionary and structuralist thought that acknowledges the structural heterogeneity of the productive sector, and argues that what a country produces and exports matters for its growth and development trajectories. According to this view, different production activities are characterised by different returns, face different demand elasticities and have different potential to generate technological spillovers (Lall, 2000). Based on these considerations, it is also argued that specialising in technology-intensive activities matters for the future growth prospects of both developed and developing countries (Nelson and Winter, 1982; Fagerberg, 1988; Fagerberg et al., 2007; Cimoli et al., 2009; Dalum et al., 1999; Lall, 2000). Some of the most recent contributions within these strands of the literature on economic development also underline the key role of certain specific MHT industries, including machinery and equipment and machine tools in particular, to develop and strengthen a country's industrial capabilities (Andreoni and Gregory, 2013; Andreoni and Chang, 2019). Finally, Chapter 4 investigates two additional dimensions of heterogeneity, taking into account different groups of destination markets and different sub-periods. This allows for the capture of different patterns and trajectories under the surface of a homogenous full sample crowding-out effect.

Quantitative research in these two chapters has been conducted rigorously to ensure that the analysis meets the criteria of internal validity, robustness and replicability (Pickbourn and Ramnarain, 2016). For both chapters, replicability is ensured in a narrow and wide sense through the possibility of implementing the same research on the same data or on data from other contexts, respectively.[22] Furthermore, the plausibility of the results has been tested through sensitivity analysis (i.e., robustness checks), while the threats to the internal validity of my regressions have been addressed using instrumental variables (IV) estimation. In particular, this latter empirical strategy has been used to shed some light on the causal relations between the increasing Chinese import competition and both the growth dynamics of South Africa-based manufacturing firms and the South African exports of MHT products to third countries, in the presence of unmeasured confounders.

Close to the spirit of those non-mainstream economists adopting a favourable position with respect to the use of econometrics in social sciences (Hoover, 2002; Downward and Mearman, 2002), econometric models are adopted in this thesis to reveal unobvious and robust partial event regularities constituting useful complements to qualitative research.[23] To this purpose, however, econometric results and causal effects have been more cautiously interpreted than is usual in mainstream applied economics (Downward et al., 2002; Castellacci, 2006). The possibility of generalising the econometric findings (i.e., their external validity) is not guaranteed and hinges on very specific preconditions, since, in line with the epistemological stances reviewed in Section 2.2, the key objective of the analysis is to uncover partial event regularities, and to identify the underlining context-specific and far-from-universal causal explanations (Lawson, 1997). In this sense, econometric exercises conducted in Chapters 3 and 4 are seen as a meaningful way to organise empirical

[22] The datasets used in this thesis, and the codes developed to build and analyse them, are available upon request. An exception is made for the tax administrative data at the firm level used in Chapter 3, which is confidential. This dataset has been accessed exclusively through the data terminals of the data centre located at the Economic Policy Unit of the National Treasury, in Pretoria, between September 2018 and March 2019. Thus, the dataset used in Chapter 3 cannot be published as part of a replication package or in an openly accessible trusted data repository.

[23] The use of econometrics in open system ontology is highly controversial (Lawson, 1989 and 1997). In fact, from a critical realist point of view, "econometric exercises inevitably imply the attempt to create experimental conditions by artificially closing the inherently open economic system" (Castellacci, 2006). However, many critical realists, as well as Post Keynesian, evolutionary and structuralist economists, have pointed out that all methods used to conduct empirical analysis assume a certain degree of 'closure' and that quantitative methods, including econometrics, are key instruments to generate in-depth understanding and explanation of an open, complex, structured and dynamic reality (Downward and Mearman 2002; Baghirathan et al., 2004; Castellacci, 2006).

evidence on the one hand, but, on the other hand, they are not supposed to have absolute validity (i.e., they aim to explain historically and geographically contingent phenomena).

While providing important and innovative results, the empirical methods used in Chapters 3 and 4 remain problematic in terms of the type and limitations of secondary data that they employ. Precisely because of the very nature of this data, Chapter 3 and 4 still assume, at least to some extent, a certain degree of homogeneity between sectors and firms, without being able to fully take into account the complex and context-specific dynamics that underpin empirical findings, and that are not always easily quantifiable.[24]

Furthermore, Chapters 3 and 4 aim to estimate the net average effect of a particular variable (i.e., the rise of Chinese import competition in South Africa and in third markets) across a large population (i.e., South Africa-based firms and South African exported products). This approach to causality, which is typical of econometric methods, does not allow for the investigation of distinct combinations of causes that may be interrelated and may reinforce each other (i.e., the rise of powerful first tier multinational suppliers in GVCs beside the increasing role of China as both an assembly-export platform and a technology producer).

This is why the valuable insights from Chapter 3 and 4 need to be complemented by more granular deep dives into the reality of specific sectoral value chains and firms operating along them in the context of a middle-income country like South Africa.

2.4 Beyond econometrics: a mixed method study based on field research

These considerations motivate the choice of conducting field research and of using a mixed methods case study approach in Chapter 5 to investigate the relationship between foreign competition stemming directly or indirectly from Chinese and non-Chinese companies, firms' capabilities, upgrading and value capture trajectories in the South African mining equipment value chain. While narrowing down the specific cluster of medium-high technology sectors considered, this chapter allows the scope of the analysis to be broadened by looking at key aspects of the rising Chinese competition (i.e., its drivers,

[24] It is also important to point out that, more generally, secondary quantitative data for most sub-Saharan African countries is often of dubious quality and thus its use can lead to a serious misunderstanding of the process of development (Jerven, 2013). This issue is perhaps less acute in a country like South Africa, which has a relatively stronger statistical capacity. However, it is important to bear this in mind when conducting research in other developing countries and especially in many sub-Saharan African ones. In these cases, the collection of primary qualitative information through field research might help to overcome this limitation.

forms and effects) that are not necessarily accessible through the study of secondary quantitative data by means of statistical and econometric methods.

Specifically, a cross-sectional retrospective case study research strategy has been adopted. This has been based on primary information (both qualitative and quantitative) gathered by means of 49 in-depth, semi-structured interviews and two focus groups conducted in South Africa between January and October 2019. Due to time and financial constraints, I have followed a non-probability purposive and snowballing sampling approach to select precisely the most strategic and relevant firms operating in the mining equipment sector, both globally and in South Africa. Triangulation and follow-up questions have been used to balance out the typical methodological limitations associated with semi-structured interviews. Finally, primary data has been complemented with secondary quantitative and qualitative information to check for inconsistencies and overlaps.[25]

Mixed methods case studies of this kind, combining quantitative findings and qualitative information from both primary and secondary sources, are strongly encouraged from a critical realist perspective (Downward and Mearman, 2002). Moreover, they are commonly adopted in a number of research areas relevant for the present thesis, such as GVC and GPN empirical contributions, innovation and development studies, international business and general management applied literature.

Specifically, the use of such an approach in Chapter 5 of this thesis responds to two fundamental needs. First, quantitative and qualitative data gathered during field research contributes to *contextualising* quantitative findings based on secondary sources by exploring the meaning and mechanisms of specific processes. Field information, indeed, helps to further explain the stylised facts highlighted in the same chapter (Chapter 5) using available quantitative indicators, and to qualify and interpret more accurately the econometric results in Chapter 3 and Chapter 4. Contextualising quantitative research findings on industrial dynamics is indeed critical in the case of a middle-income country like South Africa, characterised by dramatic social tensions and extreme inequalities (Tregenna, 2011a and 2012; Tregenna and Tsela, 2012), as well as low growth, high unemployment, lack of structural transformation (Andreoni and Tregenna, 2020) and a persistently high concentration on (Fine and Rustomjee, 1996) and within (Makhaya and Roberts, 2013) core upstream minerals-energy complex industries. In this respect, formal and informal

[25] See Section 5.4 of Chapter 5 and Section C.2 of Appendix C for more details on the data, methods and research tools employed, as well as their strengths and limitations.

conversations with key informants from both the public and private sectors in South Africa provided rich and contextual information on the state and historical dynamics of the industrialisation process in the country. This background material has been fundamental in elaborating meaningful interpretations of the results derived from the analysis of secondary quantitative data.

Second, the use of own primary qualitative and quantitative information gathered through field research makes it possible to explore *additional spheres of knowledge* that are not necessarily accessible through the analysis of secondary quantitative data by means of statistical and econometric methods. In the case of this thesis, field data has been particularly useful for overcoming a number of the data limitations that characterise Chapters 3 and 4 (Section 2.4.1) and for investigating distinct and complex combinations of causes that may be interrelated and may reinforce each other (Section 2.4.2). These two aspects are explored in more detail in what follows.

2.4.1 Overcoming the limitations of secondary quantitative data

The collection of field information through in-depth, semi-structured interviews and factory visits allows for the exploration of aspects that may not be fully captured by exclusively using the available quantitative datasets. These include: (a) the international fragmentation of production, (b) the heterogeneity at the firm level in terms of capabilities and strategies, and (c) the sectoral interdependencies in today's 'glocal' production systems.

a. Capturing the international fragmentation of production

One of these aspects is represented by the new reality of international trade, in particular the emergence and consolidation of global value chains in many industries over the past three decades. This is not fully addressed in Chapters 3 and 4. In fact, the trade data used in these chapters, provided by the UN Comtrade database, represent gross exports. As a result, the export volumes used to build key variables and indicators are those recorded when products are shipped across the border of the exporting country (i.e., China or South Africa). This means that the analysis in Chapters 3 and 4 takes into account the roles of these two countries as assembly and export platforms in global production networks, without being able to isolate and study the production and assembly processes going on within their borders and linked to their export activities.

The choice of using traditional bilateral trade figures instead of trade in value added data in the econometric analysis in Chapters 3 and 4 is motivated by the fact that the latter are not currently available for sectors and products at a very disaggregated level, for the same time period and/or for the same number of destination countries under consideration in Part I. In fact, the three most widely used inter-country input-output databases only cover a limited number of years, countries and/or manufacturing sectors.

First, the last release (2016) of the World Input-Output Database (WIOD) covers 28 EU countries and 15 other major global economies from 2000 to 2014. However, it only reports data for 23 manufacturing sectors and for a limited number of emerging countries, including China but excluding South Africa (Timmer et al., 2016). Second, the last version of the EORA multi-regional input-output database covers many more countries (i.e., 190), between 1990 and 2018, but only for eight manufacturing sectors. Although EORA has the most extensive country coverage among the databases discussed here, the national input-output tables for many of the countries included are not available and have been estimated (Lenzen et al., 2012 and 2013; Casella et al., 2019). At the aggregate level, data from the EORA database seems to do a satisfactory job of capturing global value chain participation. However, this is not the case at the industry level (Kowalski et al., 2015). Finally, the last release (2018)[26] of the Trade in Value Added (TiVA) database covers 64 economies, including all OECD, EU28 and G20 countries, most East and Southeast Asian economies, and a selection of South American ones. This edition covers the period from 2005 to 2015, with some preliminary projections to 2016 for selected countries. However, while it reports data for both China and South Africa, it only covers 16 manufacturing sectors (OECD, 2019).

From this brief overview of available inter-country input-output databases it follows that their use in the econometric analysis in Chapters 3 and 4 would have actually reduced the time-, sector-, product- and/or country-coverage. In fact, the analysis in Chapter 3 looks at the effects on South Africa-based firms of import competition stemming from China in 42 different sectors (2010-2017), while Chapter 4 estimates whether and to what extent the rise of China's exports in MHT manufacturing products at the 6-digit level has displaced (or complemented) South African exports to 178 third markets in the same product categories (1995-2018). Nonetheless, for descriptive purposes, this thesis makes use of a

[26] The 2020 version of the OECD-TiVA dataset, covering the period 1995-2018, had still not been published when this thesis was submitted.

number of indicators computed from the OECD-TiVA data, and more specifically from both the 2016 and the 2018 editions.[27] This database is more reliable at the disaggregated sectoral level than the EORA dataset and, contrary to the WIOD, it includes South Africa as well as China.

Collecting primary data on firms' operations, as was done during field research for Chapter 5, enables the researcher to capture key aspects of the international fragmentation of production by identifying the activities performed in-house by the firm itself and outsourced to third parties, as well as by tracing the geographical origin of the sourced inputs and the location where each task is carried out. Information from semi-structured interviews also allows for the analysis of the complex network of interactions among firms, and thus for the development of a deep understanding of the prevailing forms of governance and power asymmetries characterising a specific value chain. These latter aspects, indeed, are hardly quantifiable using available secondary data.[28]

b. Capturing heterogeneous firms' strategies and capabilities

A second aspect not necessarily accessible through the analysis of secondary quantitative data by means of statistical and econometric methods is related to heterogenous firms' strategies and their capabilities. The very nature of the firm-level data used in Chapter 3, for instance, prevents any attempt to capture firms' strategies, while allowing only the use of some indirect and input measures of process innovation, product innovation and skills development as proxies for firms' production and technology capabilities.[29]

With respect to the former, and in line with applied empirical studies within international business and management literature (Crick and Spence, 2005; Dong and Glaister, 2006;

[27] The 2016 edition of the OECD-TiVA dataset covers the same number of countries and industries as the 2018 version, but for 17 years, from 1995 to 2011. While this version of the dataset is quite outdated, it is used here together with the 2018 edition, which covers more recent, albeit fewer, years (11, from 2005 to 2015). Unfortunately, these two databases cannot be combined since they are based on different versions of the System of National Accounts (SNA).

[28] In this respect, notable exceptions can be found in Banga (2017) and Bontadini (2019). Both studies try to quantify different types of governance structures and analyse the impact of power asymmetries for firms in developing countries (i.e., India and Colombia, respectively). The analysis by Banga (2017) is based on a detailed firm-level database, including variables on employees' skills and supplier competences, and the study by Bontadini (2019) uses a firm-level database, including information on buyer-supplier relations. Unfortunately, similar data is not available for South Africa-based firms.

[29] These are investment and spending intensities in capital, innovation activities (i.e., R&D, royalties and patent rights) and personnel training. Unlike innovation surveys, as a tax administrative dataset, the data source used in Chapter 3 does not provide any direct and output measure on process and product innovation, and it does not include any information on the skills levels of employees. Furthermore, these indirect proxies of capabilities are of a general nature (i.e., not specific to the sectoral value chain being studied). For further details on this see Chapter 3, Section 3.3.

Deng, 2009), information gathered through in-depth conversations with firms' representatives have been extremely important for understanding the strategic motives behind firms' operations and internationalisation trajectories. As far as the latter are concerned, collecting primary information on firms' operations, production and value addition processes, as well as on their positions along the value chain, enables the researcher to open the black box of manufacturing production and to elaborate detailed capabilities matrices specific to the sectoral value chains being studied, as achieved in Chapter 5. This would not have been possible without visiting the shop floors of plants and factories, talking to managers and technical employees, and getting a sound understanding of terms and concepts drawn from other disciplines, including engineering and operation management studies (i.e., mass customisation principles, modularisation, standardisation, engineering-to-order production models, among others).

c. Capturing sectoral interdependencies in today's 'glocal' production systems

The econometric analyses conducted in Part I of this thesis employ traditionally defined industrial sectors, denoted by standard industry codes (e.g., ISIC and SITC), as the key heuristic tools for grouping together firm-level (Chapter 3) and product-level (Chapter 4) observations.

However, even though traditional sectors have been the key units of analysis in industrial economics, in the second half of the last century their adoption as the focal points of economists' attention was questioned in the literature (Rosenberg, 1963).[30] Early attempts at overcoming the concept of traditional industrial sectors include the notions of *Marshallian industrial districts* (Beccattini, 1989) and *development blocks* (Dahmen, 1989), both of which see in complementarities across different sectors – even if defined in a different and specific manner – the fundamental relationships for aggregating productive units.

More recent contributions have also underlined that traditionally defined sectors are becoming increasingly inadequate as ways of aggregating production activities, and analysing value creation and value capture dynamics in today's 'glocal' production systems (Andreoni, 2018). In particular, their use as the main units of analysis prevents any in-depth understanding of the symbiotic interdependences between manufacturing and production services (Andreoni and Lopez, 2012). According to these studies, the inadequacy of these

[30] According to Rosenberg (1963, p. 422), indeed, the "Marshallian concept of an industry" is not adequate to capture key aspects of technological developments in the American production of machine tools in the nineteenth century.

traditional heuristics is due to a number of reasons, including the emergence and consolidation of global and regional value chains, the increasingly blurred sectoral boundaries due to the outsourcing of knowledge-intensive production activities, and the growing complexity of products and technology platforms. Based on this evidence, over the past three decades many scholars have proposed a number of alternative heuristics to capture the complex nature of these 'glocal' production systems, focusing on their global dimensions – as in the GVC and GPN analytical frameworks (Gereffi, 2013; Coe and Yeung, 2019) – and local characteristics and internal dynamics – as in the literature on districts (Beccattini, 1989; Best, 1990; Andreoni et al., 2016), clusters (Lin et al., 2006; Pitelis, 2012), innovation systems (Markard and Truffer, 2008; Hekkerts and Suurs, 2007; Malerba, 2002) and ecosystems (Sturgeon, 2002; Brusoni and Prencipe, 2011).

Building on a critical review of these contributions, Andreoni (2018) proposes a new framework for the analysis of modern industrial ecosystems, structured around the concepts of capability domains and sectoral value chains. The former refers to the distinctive sets of resources and capabilities developed by the heterogeneous firms, intermediaries and institutions embedded in an industrial ecosystem. The latter are defined as productive subsystems where different types of organisations and institutions are identified and analysed according to the specific activities and functions they perform along the value chains (i.e., R&D, product design, production, distribution, post-sales services). These sectoral value chains are "open system unit[s] of analysis" (Andreoni, 2018, p.1623), which maintain key sectoral distinctive characteristics, but, at the same time, cannot be constrained within the traditionally defined sectoral boundaries.

The empirical investigation conducted in Chapter 5 is guided by an analytical framework which makes extensive use of the concepts of GVC/GPN, sectoral value chain and capability domains. The complex reality of the South African mining equipment value chain, where foreign and domestic organisations, having developed distinctive pools of resources and capabilities, participate, to varying degrees, in global and regional production systems, would not have been adequately captured if available secondary industrial data had been exclusively relied on. In fact, the vast majority of this data is generally collected and organised according to standard industry classifications. Conversely, the use of in-depth interviews conducted through snowballing sampling techniques allows the researcher to include in the analysis companies which are missing from traditional sectoral datasets, but which, in every respect, belong to the specific sectoral value chain under consideration.[31]

2.4.2 Capturing complex combinations of causes

Finally, the use of a mixed methods case study approach based on field research and with a substantial qualitative component allows for the investigation of multiple, distinct and complex combinations of causes, which may be interrelated and may reinforce each other (Pickbourn and Ramnarain, 2016). This approach to causality is very different to the one adopted in Chapters 3 and 4, whose key objective is to identify a single causal pathway, estimating the net average effect of a specific variable (i.e., the rise of Chinese import competition in South Africa and in third markets) across a large population (i.e., South Africa-based firms and South African exported products).

Close to the spirit of a critical realist conception of causality as "consisting not of regularities but of real (and in principle observable) causal mechanisms and processes which may or may not produce regularities" (Maxwell, 2004, p. 247), Chapter 5 employs a combination of methods, especially qualitative, well-suited to investigating such causal mechanisms and processes, and developing causal explanations. This is achieved through the in-depth analysis of a single case, based on a relatively small sample of key informants, and of textual forms of data that retain the chronological and contextual connections between events.

In fact, on the one hand, qualitative interviews are a particularly good method for capturing causal processes as they rely on the description of a sequence of events (Weiss, 1994). In this respect, in-depth conversations with key informants conducted during field research allowed for the extensive investigation of three interrelated causal processes in Chapter 5: first, the historical trajectory of China's participation and upgrading along the global mining equipment value chain; second, the drivers of foreign competition stemming directly and indirectly from China and affecting, in particular, South African mining equipment producers; and third, after the end of the apartheid, how such external dynamics have been interacting with the simultaneous deindustrialisation process in the broader South African economy.

[31] As an example, the approach adopted in Chapter 5 allows for the analysis of manufacturing-service interfaces and the inclusion in the study of companies offering specialised production services and/or evolving towards becoming complete solution providers, which are not necessarily classified as mining equipment manufacturers in traditional sectoral or regional datasets. See Chapter 5 for further details on this.

Furthermore, on the other hand, qualitative interviews may foster the emergence of the explanatory importance of the context, showing how it is intrinsically involved in causal processes. With regard to this point, the information collected through in-depth field interviews and analysed in Chapter 5 takes into account some of the structural weaknesses of the South African institutional support system for domestic companies (i.e., distortions in the tariff schedule, poor support in export markets, technology innovation and skills development). These weaknesses, in turn, substantially contribute to fuel foreign competition and exacerbate its impact, even for firms with advanced production and technology capabilities.

2.5 Conclusions

This chapter has argued in favour of the multi-methods and interdisciplinary research approach adopted in this thesis, underlining its benefits when conducting empirical research at the interface between international trade and industrial development in an emerging country context like South Africa.

First, it has shown that the use of this research approach is consistent with the methodological positions of the three key streams of the literature guiding the empirical investigation in Chapters 3 to 5, namely evolutionary and structuralist economics, and critical approaches to global value chain analysis. Second, it has explained why a carefully designed combination of econometric analyses based on quantitative secondary data (Chapters 3 and 4) and a mixed methods case study based on quantitative and qualitative data from (own) primary and secondary sources (Chapter 5) has proved particularly effective in shedding new light on different aspects of the main research topic of this thesis.

On the one hand, econometric models and large, available quantitative datasets have been fundamental for testing a number of hypotheses with respect to the impact over time of Chinese import competition on the growth dynamics of South Africa-based manufacturing firms (Chapter 3) and on the South African exports of MHT products to third countries (Chapter 4). On the other hand, the mixed methods case study approach adopted in Chapter 5 has allowed the empirical findings of the previous chapters to be contextualised and complemented. In particular, field data has been particularly useful in overcoming a number of the data limitations characterised by Chapter 3 and 4, and for investigating distinct and complex combinations of causes, which may be interrelated and may reinforce each other. Furthermore, this information gathered through field research has also been particularly critical also for informing policy-making. In fact, it has contributed decisively to the development in Chapter 5 of a set of policy prescriptions far more specific and targeted than those contained in Chapters 3 and 4.

However, while in this chapter I have been arguing strongly in favour of combining different methods with the aim of presenting a more comprehensive picture of the world we, as economists, are attempting to explain, I am also aware that this approach is not particularly common within the discipline of economics. As underlined by Pickbourn and Ramnarain (2016), our methodological choices are, in practice, often constrained by many factors, including the emergence and consolidation of certain 'rules' within the discipline, "which shape the expectations of our peers and colleagues regarding what counts as *real* economics; the pressure to *publish or perish*; as well as our own training, or rather the lack thereof, in methods other than quantitative techniques" (Pickbourn and Ramnarain, 2016, p. 88, italics added).

Given the relevance of these impediments and the difficulty of breaching them in practice, the methodological approach described here contributes substantially to the originality of this thesis. It shows that combining the use of state-of-the-art econometric techniques and qualitative methods to tell different parts of the same story is not only justified by epistemological and ontological considerations and, thus, desirable, but also feasible and recommended.

PART I

The econometric evidence

Chapter 3

Chinese import penetration and the growth dynamics of manufacturing firms in South Africa

3.1 Introduction

The opportunities and challenges associated with increasing South–South trade and GVC integration have taken centre stage in the academic and policy debates across developing countries (Amighini and Sanfilippo, 2014; UNCTAD, 2015; Amendolagine et al., 2019). China looms large in these discussions, given the massive gains it has made in its world shares of MVA and exports since the mid-1990s (Haraguchi et al., 2017; Lin, 2011).

Although the bulk of China's increase in absolute and relative manufacturing capacity was concentrated in the decade from 1995–2005, a significant process of expansion and consolidation of the country's global heft can also be observed immediately after the GFC. Between 2010 and 2017, China experienced a 65% increase in its MVA, accounting for over 70% of the worldwide increase in MVA that occurred in low- and middle-income countries (LMICs). During the same period, China was responsible for over 53% of the total increase in global manufacturing imports in other LMICs. In 2017, China accounted for over 90% of total manufacturing exports intra LMICs, and from 2010 to 2016 the domestic value added of its gross manufacturing exports to non-OECD economies increased by 5 percentage points, from around 76% to over 81%.[32]

The dramatic expansion in Chinese commercial power and the country's ongoing upgrading from global assembler to parts provider and system integrator along GVCs, even in some advanced manufacturing technology segments (Fu, 2016; Zhou et al., 2016; Tassey, 2014), opens up important questions regarding its impact on the rest of the world. This is particularly the case for LMICs witnessing 'primarisation dynamics' and experiencing 'premature deindustrialisation' and deteriorating trade imbalances (Jenkins, 2014 and 2015; Tregenna, 2015). An often-raised concern is that the increasing competitive pressure exerted by Chinese imports on manufacturing industries in other developing

[32] Own calculations using data from INDSTAT (2018), UN Comtrade (2018) and OECD-TiVA (2018).

countries with weaker technology and production capability bases might limit the breadth and depth of their industrial development (Paus, 2019; Andreoni and Tregenna, 2020; Kaplinsky and Morris, 2008; Lall et al., 2005; Lall and Alaladejo, 2004).

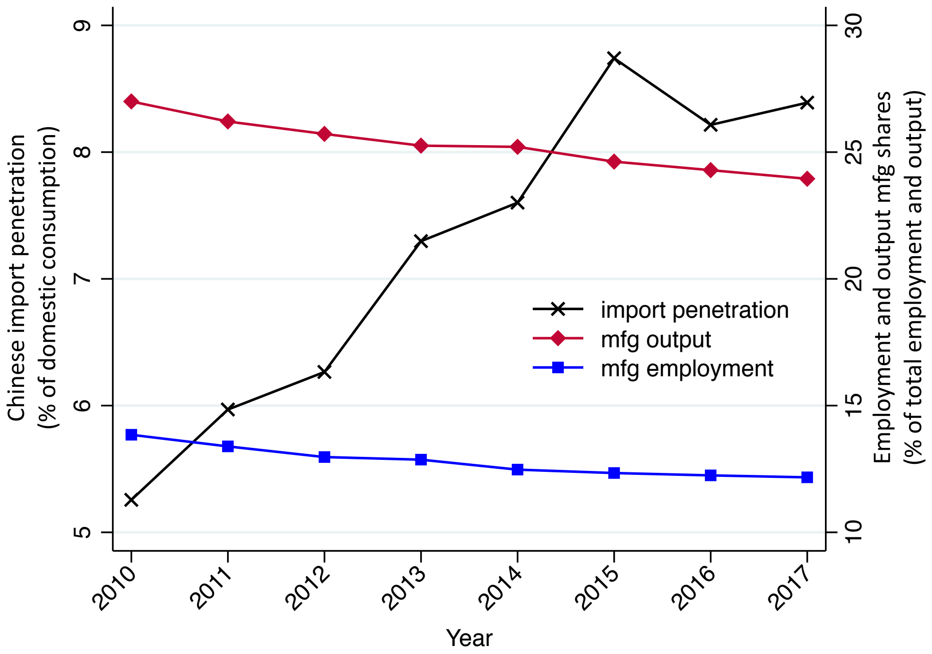
The past decade has seen an increasing amount of empirical literature investigating the impact of Chinese import competition on firm performances in advanced economies (Bernard et al., 2006; Colantone et al., 2015; Bloom et al., 2016; Hombert and Matray, 2018; Mion and Zhu, 2013). However, due to the limited availability of longitudinal micro-datasets, only a few studies have been able to produce econometric evidence on the impact of Chinese import competition for LMICs (Alvarez and Claro, 2009; Iacovone et al., 2013). Even in these limited cases, the heterogeneous and systemic impact of import competition have been only partially addressed.

The recent availability of tax administrative data for South Africa-based companies makes it possible to fill this knowledge gap and generate new evidence on the impact of Chinese import penetration on manufacturing firms in a major middle-income country. To the best of my knowledge, this is the first empirical firm-level study to investigate this issue in South Africa.

South Africa provides an excellent policy-relevant case study as well. Since the end of the apartheid era, South Africa's increasing integration into the global economy and the ongoing intensification of import competition from China have gone hand-in-hand with severe unemployment, poor growth performance and persistent structural transformation challenges (Andreoni et al., 2021a). In particular, the increasing import competition stemming from China has prompted an active debate about the deindustrialisation and 'primarisation' trajectories of the South African economy, and its impact on domestic manufacturing production and employment (see also Chapter 1 on this).

Using aggregate industry data, Figure 3.1 reports on the surge of Chinese manufacturing imports entering South Africa and also provides suggestive evidence of the shrinkage of the domestic manufacturing sector during the period under analysis. From 2010 to 2017, Chinese imports in South Africa's manufacturing sector grew rapidly from 5% of total domestic consumption to over 8%, while the shares of manufacturing in total output and employment showed a slow but steady declining trend.

Figure 3.1. Trends in manufacturing output and employment, and Chinese import exposure in South Africa, 2010–2017.



Note: The import penetration ratio for South African imports from China (left scale), share of South African manufacturing output (employment) in total output (employment) (right scale).
Source: Own calculations using UN Comtrade (2018) and Statistics South Africa (2018a and 2018b).

Despite these concerns, no comprehensive studies have attempted to investigate the impact of Chinese import penetration on the growth dynamics of manufacturing firms in South Africa. In the present chapter, I use a unique firm-level database, recently made available by the South African Revenue Service (SARS), to fill this knowledge gap, in two ways. First, I study whether China's import competition has been associated with a downsizing of manufacturing firms in terms of decreasing employment and sales growth, and higher probability of exiting the market, both within the same sector (impact of direct import penetration) and along domestic value chains through input-output linkages (impact of indirect import penetration). Secondly, I analyse whether firms investing relatively more intensively in certain technology and productive capabilities – notably process and product innovation, and skills development – are better able to cope with Chinese import competition. This research strategy allows for the unpacking of both the heterogeneous and systemic impact of Chinese import penetration on South Africa's manufacturing firms.

The empirical results indicate that, at the industry level, rising exposure to Chinese imports – not only direct ones, but also in downstream segments of the domestic value chain –

leads to slower sales and employment growth for the entire sample of surviving firms, and to a higher probability of shutdown for firms that do not undertake significant investments in capabilities development. However, I also find that, within industries, firms investing relatively more intensively in skills development, and product and process innovation, are more likely to survive and grow in the wake of import competition.

The remainder of the chapter is organised as follows. Section 3.2 reviews the relevant literature on the impact of import competition on the growth dynamics of manufacturing firms. I contextualise this literature by considering the specific ways in which a surge in Chinese import penetration can impact relatively less developed industrial systems such as South Africa's. Section 3.3 introduces the data and describes the empirical strategy. Section 3.4 presents a preliminary descriptive analysis. The main econometric findings are summarised and analysed in Section 3.5. The final section provides concluding remarks.

3.2 Related literature

Since China's surge in international trade, a large body of literature has analysed the impact of Chinese import penetration on the domestic production systems of both developed and developing countries, focusing on different dimensions and levels of aggregation, for example, plants, firms and industries, but also local labour markets. Several studies of industries and local labour markets have documented the contractionary effects on manufacturing employment of the competitive pressure driven by the surge of Chinese imports, both in advanced (Acemoglu et al., 2016; Autor et al., 2013; Balsvik et al., 2015; Donoso et al., 2015; Malgouyers, 2016) and emerging (Mendez, 2015; Paz, 2018) countries.

Other plant-level and firm-level studies have found similar negative effects of increasing Chinese import penetration in terms of employment growth, output growth and survival rates in the manufacturing sector. In an influential treatment of trade impacts on United States manufacturing, Bernard et al. (2006) found that, during the period from 1977–1997, plants more exposed to import competition from low-wage countries – with China being by far the largest member of this group – grew more slowly and were more likely to exit the market. Similarly, Mion and Zhu's (2013) study of Belgian manufacturing firms between 1996 and 2007 indicated that industry-level import competition from China reduced firm employment growth without affecting firm survival. Colantone et al. (2015), using industry-specific exit rates for the population of large and small firms in eight European countries, showed that, between 1998 and 2003, relatively large firms involved in high-scale production displayed higher exit rates in response to increasing import competition stemming from low-cost countries, including China.

However, due to the limited availability of extensive firm-level longitudinal datasets across developing and middle-income economies, there is only limited knowledge of the impact of Chinese import penetration on the growth dynamics of manufacturing firms located in these countries. One of the few systematic studies was conducted by Alvarez and Claro (2009), who found that, over the period 1990–2000, Chinese import penetration drove a decline in employment growth and survival rates for firms in the Chilean manufacturing sector.[33] An additional empirical assessment was conducted by Iacovone et al. (2013), who evaluated the effects of increasing Chinese import competition for producers in another middle-income country (i.e., Mexico), taking into account firm heterogeneity in terms of size. Employing a quantile regression approach, they showed that sales of smaller plants and more marginal products shrink substantially and are more likely to further decline toward zero, whereas those of larger plants and core products seem relatively more resilient to increased import competition.

Nonetheless, while size matters in responding to competitive pressures, there is little evidence on the additional features that allow certain firms to better cope with rising import penetration. A notable exception is represented by the work of Bernard et al. (2006), who showed that capital- and skill-intensive plants in the United States are more likely to survive and grow in light of increasing import competition, consistent with the predictions of the firm-level variant of the Heckscher–Ohlin model.[34] In a recent study, Hombert and Matray (2018) started to shed light on the role of other firm characteristics in mitigating the impact of Chinese import competition on United States manufacturing plants from 1991 to 2007. They demonstrated that firms with larger stocks of R&D are more resilient to such trade shocks, downsizing considerably less than those with smaller R&D stocks.

I add to this emerging literature by testing the relevance of the mediating role of the intensity of firm-level investments in process innovation, product innovation and skills

[33] Contrary to both the predictions of the factor-endowment-driven specialisation framework and the empirical evidence for advanced economies (Bernard et al., 2006; Mion and Zhu, 2013), Alvarez and Claro (2009) found no evidence of any pro-competitive and upgrading effect on capital and skill deepening, productivity catch-up, or increased exporting activities. They associated these negative findings with the low levels of capital and skilled labour, which may have limited the ability of Chilean firms to move towards producing more sophisticated goods in response to import competition.

[34] However, within the context of middle-income countries, Alvarez and Claro (2009) found no evidence of any reallocation effect towards relatively more capital- and skill-intensive firms.

development on the relationship between import competition and firm growth dynamics. This is very much in line with recent empirical studies on firm dynamics (Bottazzi et al., 2010; Dosi et al., 2012; Dosi et al., 2015b; Mathew, 2017; Dosi and Yu, 2019), which point to the heterogeneity in firm-level characteristics as the main source of differences across firms' performances. In principle, the investments mentioned above, which are used here as measures of the innovative potential and efforts of firms, can moderate the effect of trade shocks on firm growth and performance through different channels, such as an increase in productivity (Grossman and Helpman, 1991; Lichtenberg and Siegel, 1991; Aghion and Howitt, 1992), in product differentiation (Sutton, 1991) and market and/or product diversification (Coad and Guenther, 2014).

These hypotheses are strongly supported by Schumpeterian, resource-based and capability theories of the firm (Penrose, 1959; Amsden, 1997; Dosi et al., 1990 and 2000; Lall, 1992 and 1999; Teece, 1986; Lin and Chang, 2009), which suggest firms' reactions to competitive pressure are highly heterogeneous as they critically depend on their different capabilities, specifically how they organise these capabilities in response to changing opportunities, incentives and rising competitive challenges. The above authors have emphasised the importance of technology and productive capabilities (such as skills, physical investments, technological and innovation efforts) for firms to manage and advance technological change (Bell and Pavitt, 1993; Lall, 1992; Lee, 2013; Penrose, 1959), to absorb technologies (Cohen and Levinthal 1989), to benefit from participation in trade (Dosi et al., 1990; Lall, 1999) and GVCs (Andreoni, 2019; Lee et al., 2018; Milberg and Winkler, 2013; Morrison et al., 2008), and to reconfigure and renew themselves to be able to rapidly adapt to and capitalise on changes in the external environment (Teece and Pisano, 1994; Winter, 2003; Wang and Ahmed, 2007).

The present work also relates to the literature on the diffusion of shocks (Acemoglu et al., 2012; Contreras and Fagiolo, 2014) and FDI spillovers (Javorcik, 2004; Javorcik and Spatareanu, 2011; Newman et al., 2015) through the input-output network of an economy. Following a methodology similar to those developed by Acemoglu et al. (2016) and Pierce and Schott (2016), the present empirical analysis also takes into account the impact of indirect Chinese import penetration and competitive pressure spreading from directly affected firms to others through input-output linkages in downstream and upstream industries.[35]

The importance of disentangling the impact of this form of indirect import penetration is also inspired by structuralist multi-sectoral models and structural development economics literature emphasising the importance of these intersectoral linkages in countries' economic structures, and how a number of different shocks (such as targeted policies, investments, opening to trade, linking to GVCs), acting upon these industrial interdependencies, might force countries towards extremely diverse development paths (Hirschman, 1958 and 1997; Bahar et al., 2019; Chang and Andreoni, 2020).

In the post-apartheid period, rapid trade liberalisation represented a major shock for South African industries. Since then, the lack of dynamism of the manufacturing sector has been regarded as a key factor in explaining stagnant growth and persistently high unemployment levels (Fedderke, 2006; Rodrik, 2008; Jenkins, 2008c; Tregenna, 2016b; Andreoni et al., 2021a). These weak performances and various other signs of premature deindustrialisation have also been associated with the competitive pressure from imports resulting from the multilateral trade reform of the early 1990s (Erten et al., 2019; Rodrik, 2008; Jenkins, 2008c) and, more recently, from the rapid growth in imports from China following its accession to the WTO in 2001 (Edwards and Jenkins, 2015).

Detailed sectoral analysis and case studies of the implications of Chinese imports for South Africa generally find adverse effects on domestic production and employment, and a crowding out of exports to third countries (Edwards and Jenkins, 2014 and 2015; Jenkins and Edwards, 2015; Morris and Einhorn, 2008). On the one hand, Morris and Einhorn (2008) showed how import competition from China in the South African clothing and textile sector enhances consumer welfare, while leading to a negative employment effect in the domestic industry. On the other hand, using Chenery-style decomposition techniques, Edwards and Jenkins (2015) documented that labour-intensive industries exposed to import competition from China suffered large employment declines from 1992 to 2010. Overall, these studies suggest that the competitive pressure exerted by Chinese exports to South Africa has increased rapidly over recent decades, partly at the expense of

[35] However, the specifications proposed by Acemoglu et al. (2016) and Pierce and Schott (2016) differ from mine in some essential aspects. In particular, Acemoglu et al. (2016) regressed the change in log employment at the level of manufacturing industries (rather than firms) on changes in the Chinese import penetration rate (rather than its previous level).

imports from third countries, but more importantly crowding out the domestic manufacturing production.

While these contributions provide important industry-specific evidence of the effect of import penetration from China, detailed case studies cannot be easily generalised and sectoral-level analyses employing decomposition techniques do not shed any light on firm-level heterogeneous dynamics triggered by Chinese import penetration. In particular, they do not allow the testing of a number of hypotheses related to the growth trajectories of manufacturing firms and how their different capabilities play a mediating role. The present study, by contrast, fills this gap in the literature by providing the first micro-level evidence of the impact of direct and indirect Chinese import penetration on the growth dynamics of South Africa-based manufacturing firms.

3.3 Data and methods

3.3.1 Main data sources and variables

This study uses information from three different sources. Import penetration variables – direct and indirect – are constructed using trade information provided by the UN Comtrade database, and production and input-output data made available by Statistics South Africa, while firm-level data from company and employee income tax certificates are obtained from SARS.

3.3.1.1 Measuring direct import penetration

The main industry-level import penetration variable is computed as the ratio of sectoral imports from China (PEN^{CHN}) to domestic sector-specific consumption in each year. Analytically:

$$PEN_{s,t}^{CHN} = \frac{M_{s,t}^{CHN}}{M_{s,t}+Y_{s,t}-X_{s,t}} \qquad (3.1)$$

where $M_{s,t}^{CHN}$ is the value of imports from China in sector *s* in year *t*; $M_{s,t}$ is the value of total imports (including China) in sector *s*, in year *t*; while $Y_{s,t}$ and $X_{s,t}$ represent the South African sectoral domestic production and exports, respectively.

Industry-level production data is provided by the Manufacturing Sales and Production database of Statistics South Africa for 42 manufacturing sub-sectors (Statistics South

Africa, 2018b).[36] Imports and exports data comes from the UN Comtrade database (UN Comtrade, 2018). Using official correspondence tables, I convert trade data at the 6-digit commodity level of the World Customs Organisation Harmonised System (HS-2007) into International Standard Industrial Classification of All Economic Activities (ISIC4) manufacturing sectors. These groups are then adjusted slightly to exactly match the industry classification adopted by Statistics South Africa.

3.3.1.2 Measuring indirect import penetration

In addition to the direct import penetration calculated as indicated above, this analysis also takes into account the impact of import penetration on the growth of firms indirectly exposed to Chinese import penetration through input-output relationships along domestic value chains. Specifically, I focus on both import penetration affecting a firm's downstream clients – *upstream effects* – and a firm's upstream suppliers – *downstream effects*. Following Acemoglu et al. (2016), to identify the upstream effect I compute the following variable for each sector *s*:

$$PEN_{s,t}^{CHN,UP} = \sum_{k} w_{k,s,2008}^{UP} \times PEN_{k,t}^{CHN} \tag{3.2}$$

which is equal to the weighted average of import penetration faced in year *t* by all the industries, indexed by *k*, that purchase inputs from sector *s*. These weights ($w_{k,s,2008}^{UP}$) are defined as:

$$w_{k,s,2008}^{UP} = \frac{\mu_{k,s,2008}^{UP}}{\sum_{k'} w_{k',s,2008}^{UP}} \tag{3.3}$$

where $\mu_{k,s,2008}^{UP}$ represents the value in the 2008 South African input-output table of the output of sector *s* purchased by industry *k*, such that the weight reported in Equation 3.3 constitutes the proportion of total sales of industry *s* that industry *k* uses as inputs within its production process. I decided to use the 2008 input-output table rather than time-varying input-output coefficients since it predates the period covered in the analysis and

[36] In order to ensure consistency with sectoral trade data, I aggregate 'Publishing' (324) with 'Printing and related services' (325/6) and 'Electrical motors, generators and transformers' (361) with 'Electricity distribution and control apparatus' (362). Tobacco products are excluded as sales data is not provided by Statistics South Africa.

thus measures sectoral interdependencies that are unlikely to be endogenous to the subsequent import penetration.[37]

Following a similar approach, I estimate the downstream effect ($PEN_{s,t}^{CHN,DOWN}$) experienced by each sector *s* as the weighted average of import penetration faced in year *t* by all the industries, indexed by *k*, from which industry *s* buys its inputs. For this purpose, I use the same formula as the one reported in Equation 3.2 after reversing the *s* and *k* indexes in the numerator of Equation 3.3.[38] The formula in Equation 3.2 refers to the direct (namely, first-order) effects on a given industry *s* arising from the import penetration exposure faced by its direct suppliers and buyers. In order to account for the full production chain of interdependent downstream and upstream linkages (such as the import penetration exposure faced by all suppliers' suppliers and buyers' buyers of sector *s*), in some additional estimates I substitute $PEN_{s,t}^{CHN,UP}$ and $PEN_{s,t}^{CHN,DOWN}$ with the entire series of implied responses from the input-output table, given by the Leontief inverse of the matrix of upstream and downstream linkages.

It is important to note that, in the present study, the import volumes used to compute the direct and indirect import penetration variables in Equations 3.1 and 3.2 are those recorded when products cross the border of the importing country (i.e., South Africa in this case). Specifically, in this chapter I focus exclusively on the gross trade figures reporting the value of manufacturing products shipped from China to South Africa, rather than on data for bilateral trade in value added between these two countries. This means that although I do take into consideration China's role as both a producer, and an assembly and export platform, in global production networks, I am not able to isolate and study the production and assembly processes going on within its borders and linked to its export activities to South Africa.

The choice of using gross trade information is primarily motivated by the fact that bilateral data in trade in value added is not currently available for the same number of years and manufacturing sectors under consideration here (see Section 2.4 of Chapter 2 for further

[37] The input-output table from 2008 has been preferred to the version from 2009, because the effects of the GFC unfolded in South Africa mainly in 2009.

[38] For the purposes of this specific empirical exercise I restrict the analysis of the impact of indirect import competition on manufacturing firms to all non-service industries. This means that all upstream and downstream effects experienced by a certain manufacturing sector emanate, by definition, from import exposure of their buyers and suppliers from agriculture, forestry, mining, manufacturing, utilities and construction (i.e., $PEN_{k,t}^{CHN}$ is set equal to zero for service industries and for final demand for both upstream and downstream import penetration effects).

details on this; a similar approach is also used in Chapter 4). However, for the purposes of this chapter I do not require China to be the sole producer of the products it ships to South Africa, although I am obviously aware that parts of these products are produced in China by export processing plants, which import key components from foreign countries, assemble these inputs and export the final goods (Srholec, 2007).

3.3.1.3 Main firm-level outcome variables and controls

The primary firm-level data source is the South African Corporate Income Tax (CIT) data, which includes firms' self-reported items with respect to income, expenditures, equity and liabilities, capital items and tax credits.[39]

Starting from this source, I use employee income tax certificates (IRP5 forms) to construct a measure of labour employed by each firm.[40] The data is then restricted to cover the population of manufacturing firms for the 2010–2017 period. In order to systematically identify manufacturing firms, I use the main industry code of the Standard Industrial Classification (SIC7), provided by the CIT database.[41] These codes are then converted to the fourth revision of ISIC (ISIC4) and adjusted slightly to exactly match the industry grouping adopted by Statistics South Africa, as described in Section 3.1.1.[42] Finally, I exclude from the sample those firms with non-positive and missing employment, sales, value added and capital data. The final full sample covers over 22,000 firm observations for each year between 2010 and 2017, distributed over 42 manufacturing sectors.[43]

Using information from the resulting dataset, I construct a battery of firm-level measures

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[39] For a full description of the dataset and how it is constructed and compiled, see Kreuser and Newman (2018). The analysis undertaken in this chapter is based on the version of the dataset available in March 2019.
[40] IRP5 data is aggregated for each pay-as-you-earn (PAYE) reference number.
[41] The two databases described above report different industry classification variables and some firms do not consistently locate themselves in a given industry within or across the different data sources. Furthermore, starting from the data release of January 2019, the main industry variable available in the CIT database and based on the raw data provided by SARS has been found to be completely unreliable. Therefore, the industry variable used in the present study has been merged from the previous version of the panel (i.e., 2010–2015) into the new dataset for each firm, based on the tax reference number and the year. For 2016–2017, sector codes have been allocated based on the last available observation for each firm. Although being, in my opinion, the best possible imputation procedure available, this approach does not allow for the identification of industry-switchers and new entrants during the 2016–2017 period.
[42] With respect to industry-switchers from 2010 to 2015, the following classification strategy is adopted. When firms change industry classifications in a single period and then revert to the original classification, I replace that period industry code with the original industry code, assuming they have never switched. When the switch in industry classification is longer than one period and continues until 2015, I assume that this reflects an actual change in industry classification. Missing industry variables are imputed using the available prior- and post-period industry codes. For the 2016–2017 period I apply the imputation procedure described in the previous footnote.
[43] Due to the absence of sectoral output data on tobacco products, as outlined in Section 3.1.1, I ignore firms operating in this industry.

of firm growth, to be used as dependent variables in the subsequent analysis. To address potential endogeneity problems, I follow Bernard and Jensen (2004) and use firm covariates at time t while considering dependent variables at time $t+1$. The first outcome variable used is firm employment growth – $\Delta\mathbf{log}\ (\boldsymbol{Employment})_{\boldsymbol{i,s}}^{\boldsymbol{t,t+1}}$ – which is defined as the log difference between a firm's full-time equivalent total employment in year $t + 1$ and t.[44] The second variable is output growth – $\Delta\mathbf{log}\ (\boldsymbol{Sales})_{\boldsymbol{i,s}}^{\boldsymbol{t,t+1}}$ – which is defined as the log difference between a firm's total sales in year $t + 1$ and t. Finally, as an additional dependent variable I consider firm exit – $\boldsymbol{Death}_{\boldsymbol{i,s}}^{\boldsymbol{t,t+1}}$ – which takes a value of 1 for firms operating in t but not operating in $t + 1$, and 0 for firms operating in both periods.[45]

For independent variables, I consider a number of covariates. First, as is standard in the literature, the log of total employment ($\mathbf{log}(\boldsymbol{E})_{\boldsymbol{i,t}}$) and the log of the number of years since registration plus 1 ($\mathbf{log}(\boldsymbol{Age})_{\boldsymbol{i,t}}$) are used as measures for firm size and age, respectively. Second, I explore the richness of the SARS dataset to identify specific firm-level variables related to investments in certain technology and productive capabilities development, to be used as indicators for the intensity of firms' expenditures in process innovation, product innovation and skills development.

Unlike innovation surveys, as an administrative dataset, this data source does not provide any direct and output measure on process[46] and product innovation.[47] Furthermore, the IRP5 forms do not include any information on the skills levels of employees.[48] To overcome these data limitations, I use indirect and input measures of production and technology capabilities as the main covariates of interest in this analysis.[49]

The relative levels of investments in process innovation are proxied by investment intensity in physical capital ($\boldsymbol{INVST}_{\boldsymbol{i,t}}$), which is measured as the yearly additions to the

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[44] I refer to this variable as full-time equivalent employment, because in calculating the total number of employees by firm, each employee is weighted by the total number of periods she or he has actually worked at that company.

[45] For firms that exit and enter the dataset many times, I consider the shutdown year to be only the one of their final appearance.

[46] Such as, for example, unit cost reduction and sales increases due to quality improvements resulting from process innovation.

[47] Such as, for example, the share of sales resulting from product innovation.

[48] Such as, for example, years of schooling, level and type of degree awarded, specific functions performed within the firm.

[49] An underlying assumption here, generally confirmed by the literature, is that the likelihood of being an innovative firm (unobserved in the case of this analysis) is positively associated with the intensity of its innovative efforts.

firm's net assets in physical capital (that is, gross assets adjusted for depreciation), normalised by sales.[50] The relative levels of spending in product innovation are measured as the ratio of R&D expenses and total sales: $\boldsymbol{R\&D_{i,t}}$.[51] Finally, the relative levels of spending in skills development are operationalised as the ratio of staff training expenses and total sales: $\boldsymbol{TRAIN_{i,t}}$.[52]

To identify those firms investing intensively in capabilities development, I build a battery of dummies taking value 1 if the investment intensity of firm *i*, in year *t* in physical capital, R&D and training programmes, respectively, is larger than the sectoral median. These are denoted below as $\boldsymbol{(d)\,INVST_{i,t}}$, $\boldsymbol{(d)\,R\&D_{i,t}}$, and $\boldsymbol{(d)\,TRAIN_{i,t}}$. Table 3.1 reports descriptive statistics on the main variables used in the regression analysis.

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50 In order to compute this variable, I use the assets in property, plant and equipment, which identify the maximum level of disaggregation with respect to physical capital included in the CIT database.

51 In particular, this variable is used as a proxy for spending intensity in internal product innovation.

52 In some unreported alternative specifications (available upon request), I normalise the spending in training activities by total full-time equivalent employment, obtaining very similar regression results.

Table 3.1. Descriptive statistics.

Variables	Mean	Std. Dev.	Min.	Max.
Firm-level variables:				
$\Delta\log(E)_i^{t,t+1}$	0.026	0.372	-1.067	1.278
$\Delta\log(S)_i^{t,t+1}$	0.020	0.337	-0.963	0.982
$Death_i^{t,t+1}$	0.04	0.214	0	1
Age_i^t	16	11.22	2	62
$Size_i^t$	47	286.67	1	30363
$INVST_i^t$	0.051	0.134	0	0.989
$R\&D_i^t$	0.001	0.022	0	0.341
$TRAIN_i^t$	0.001	0.026	0	0.132
$(d)\ INVST_i^t$	0.237	0.372	0	1
$(d)\ R\&D_i^t$	0.071	0.235	0	1
$(d)\ TRAIN_i^t$	0.085	0.286	0	1
Direct import exposure:				
$PEN_{s,t}^{CHN}$	0.094	0.097	0.001	0.537
$PEN_{s,t}^{LOW}$	0.045	0.041	0.001	0.286
$PEN_{s,t}^{ROW}$	0.176	0.160	0.024	0.810
First-order indirect import exposure:				
$PEN_{s,t}^{CHN,UP}$	0.021	0.026	0.000	0.178
$PEN_{s,t}^{CHN,DOWN}$	0.014	0.021	0.000	0.124
Full indirect import exposure:				
$PEN_{s,t}^{CHN,UP}$	0.029	0.035	0.000	0.195
$PEN_{s,t}^{CHN,DOWN}$	0.019	0.024	0.000	0.101

Notes: Mean, standard deviation, minimum and maximum values of main variables measured over the 2010-2017 period, across the full sample of South Africa-based firms. Variables are defined as described in Section 3.3.1.
Source: Own calculations using SARS data.

3.3.2 Empirical strategy and expected results

The basic concept of the present analysis is to study the impact of both direct and indirect Chinese import penetration, controlling for firm heterogeneity within industries in terms of investment in process and product innovation, and skills development. On one hand, I examine whether Chinese competition has generated a negative impact on manufacturing firms, either affecting their employment decisions, their output dynamics or their probability of closing down. On the other hand, I explore to what extent, within industries, firms investing relatively more intensively in process and product innovation, and skills development, are better able to cope with Chinese competition with respect to the outcome variables introduced above.[53] These outcomes between *t* and *t* + 1 are related to a set of year *t* firm characteristics, $V_{i,t}$, the sectoral Chinese import penetration – either direct or indirect – in year *t*, and a set of interactions, $X_{i,s,t}$, between such trade exposure variables and firm-level indicators of investments in process and product innovation, and skills development:

$$Outcome_{i,s}^{t,t+1} = f(V_{i,t}, PEN_{s,t}^{CHN}, X_{i,s,t}) \tag{3.4}$$

To facilitate interpretation, I report and interpret only estimates including interaction terms between trade exposure variables and a battery of dummies taking value 1 if the investment intensity of firm *i* in year *t* in physical capital, R&D and training programmes, respectively, is larger than the sectoral median. The introduction of these interactions allows the within-industry reallocation effect across firms to be analysed, taking into account firm-level heterogeneity in terms of certain production and technology capabilities.

More specifically, I consider three different firm outcomes. The first set of results examines the influence of Chinese imports on the employment growth of South Africa-based firms:

$$\Delta\log\,(Employment)_{i,s}^{t,t+1} = c + V_{i,t}'\alpha + PEN'^{CHN}_{s,t}\beta + X_{i,s,t}'\gamma + \delta_t + \delta_i + \varepsilon_{i,t} \tag{3.5}$$

The set of firm characteristics considered here encompasses log total employment, log age, intensity in capital investments, R&D expenditures, and spending on staff training, as defined in Section 3.3.1.3. Second, I explore the extent to which Chinese import penetration impacts the sales growth of South Africa-based firms:

$$\Delta\log\,(Sales)_{i,s}^{t,t+1} = c + V_{i,t}'\alpha + PEN'^{CHN}_{s,t}\beta + X_{i,s,t}'\gamma + \delta_t + \delta_i + \varepsilon_{i,t} \tag{3.6}$$

I examine employment and output growth on the subset of surviving firms, as well as the full sample of surviving and dying firms. The third adjustment margin analysed is the potential demise of South Africa-based manufacturing firms:

[53] In developing my methodology, I build and expand upon previous works by Acemoglu et al. (2016), Alvarez and Claro (2009), Autor et al. (2013), Bernard et al. (2006), Hombert and Matray (2018), and Iacovone et al. (2013).

$$Pr\ (Death)_{i,s}^{t,t+1} = c + V_{i,t}'\alpha + PEN'^{CHN}_{s,t}\beta + X_{i,s,t}'\gamma + \delta_t + \delta_i + \varepsilon_{i,t} \tag{3.7}$$

where δ_t and δ_i represent time and firm fixed effects, respectively. Regressions 3.6 and 3.7 employ the same firm characteristics and interaction variables as the employment growth specification in Equation 3.5. Following Alvarez and Claro (2009), and Mion and Zhu (2013), I use a linear probability model as my main specification for Equation 3.7, and not more conventional discrete choice models as probit or logit, to allow for firm-specific effects that may affect the probability of exit.

In all subsequent estimates, following Cameron et al. (2011), I employ a two-way (firm and industry) clustering approach to correct for unobservable firm- and sector-specific shocks uncorrelated with both $\varepsilon_{i,t}$ and the independent variables (on this, see also Mion and Zhu, 2013).

3.3.2.1 Instrumenting Chinese import penetration

One concern about Equation 3.1 as a measure of trade exposure in the subsequent estimations is that observed dynamics in import penetration ratio may partly reflect domestic shocks to South African industries that affect their import demand. In this case, the ordinary least squares (OLS) estimate of how imports from China affect the growth dynamics of manufacturing firms in South Africa might lead to biased results of the Chinese import penetration coefficient.[54]

To address this problem and identify the causal effect of rising Chinese import exposure on the growth of manufacturing firms in South Africa, I employ an instrumental variable (IV) approach that accounts for the potential endogeneity of trade exposure. More specifically, I instrument Chinese import penetration with China's share of imports in other LMICs (excluding South Africa).[55] Analogous to the direct import penetration measures, upstream and downstream exposure variables are instrumented by replacing the

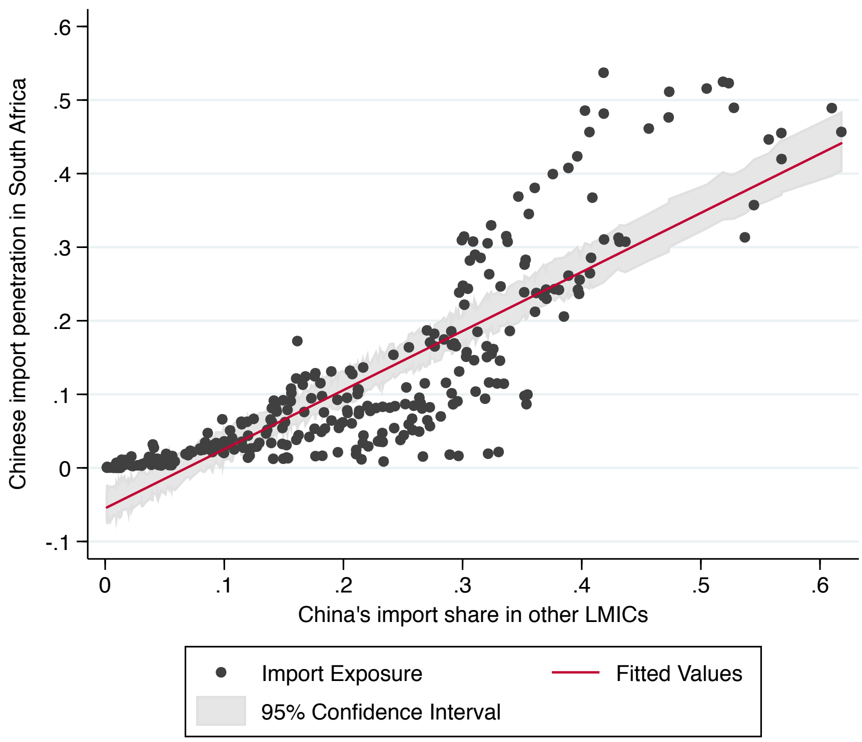
[54] The bias resulting from the simultaneity associated with South African industry import demand shocks would tend to attenuate the point estimate of interest toward zero (Autor et al., 2013; Hombert and Matray, 2018).

[55] Edwards and Jenkins (2015) employed this instrument to analyse the contribution of Chinese import penetration to rising labour productivity at the sectoral level for 44 South African manufacturing industries. Iacovone et al. (2013) used a similar instrumental approach to examine the impact of Chinese competition on Mexican manufacturing firms. I classify countries as LMICs using the World Bank definition for the 2010–2017 period.

term PEN^{CHN} in Equation 3.2 with the instrumental variable introduced in this section, while retaining the same weights.

The first-stage regression (Figure 3.2, below), with time-fixed effects and without detailed controls, confirms the strong predictive power of China's share of imports in LMICs for Chinese import penetration in South Africa.

Figure 3.2. First-stage regression, 2010–2016.



Notes: Each point represents a manufacturing industry in a specific year, from 2010 to 2016 (*N* = 294). The South African exposure to Chinese imports is defined as South African imports from China divided by South African apparent consumption; the comparison countries' exposure to Chinese imports is defined as China's share in other LMICs' imports. Lines are fitted by OLS regression. The 95% confidence interval is based on robust standard errors. The slope coefficient is 0.82 with robust standard error of 0.03; the *t*-statistic, *F*-statistic and R-squared are 24.35, 85.84 and 0.73, respectively. Time controls included.
Source: Own calculations using UN Comtrade (2018) and Statistics South Africa (2018b).

This identification strategy is inspired by Autor et al. (2013), who consider the relationship between imports from China and local labour market effects in the United States. Similar to the approach in their famous article, I also exploit the fact that much of the growth in Chinese exports during the last three decades, including the period of interest in this study, appears to be strongly related to factors that are specific to China. The historical evidence suggests that the impressive increase in the country's absolute and relative manufacturing capacity and competitiveness has been driven by massive productivity growth and extensive policy reforms (namely a supply shock from the producer perspective of South Africa and other developing countries).[56]

3.3.2.2 Expected results

Based on the previous empirical evidence reviewed in Section 3.2, my first research hypothesis points to the possibility of a negative impact of direct Chinese import penetration on the growth dynamics of manufacturing firms whose output directly competes with such imports.

Furthermore, accounting for the presence of input-output linkages within the economy, I also test the hypothesis that import penetration might indirectly affect firms' expansionary dynamics. Specifically, following the contribution of Acemoglu et al. (2016), I can expect that import penetration affecting a firm's downstream clients might reduce the demand of these clients for the intermediate or final products produced by the same upstream firm (that is, the *upstream effects*). Thus, it might further reinforce the negative effect of direct import penetration. Furthermore, the increase of competition from imports affecting a firm's upstream suppliers (that is, the *downstream effects*) might have two different effects. On the one hand, import competition might exert a downward pressure on input prices, having an expansionary effect on the activities of the procuring firm itself in downstream industries (Goldberg et al., 2010; Hombert and Matray, 2018). On the other hand, import competition might lead to the disruption of existing long-term supply agreements, with downstream firms substituting domestic suppliers with imported inputs. In this case, such a displacement can have a further contractionary effect for downstream firms. Thus, taking into account these two effects, the sign of the net impact of an increase in import competition affecting a firm's upstream suppliers is ambiguous.

Finally, irrespective of the specific underlying mechanism (increasing productivity, efficiency or product differentiation among others), I expect that firms that invest more intensively in process and product innovation, and in skills development, are relatively less affected in terms of growth and survival rates in the wake of Chinese import competition. This research hypothesis is supported by a number of theoretical perspectives and empirical evidence, as reviewed in Section 3.2.

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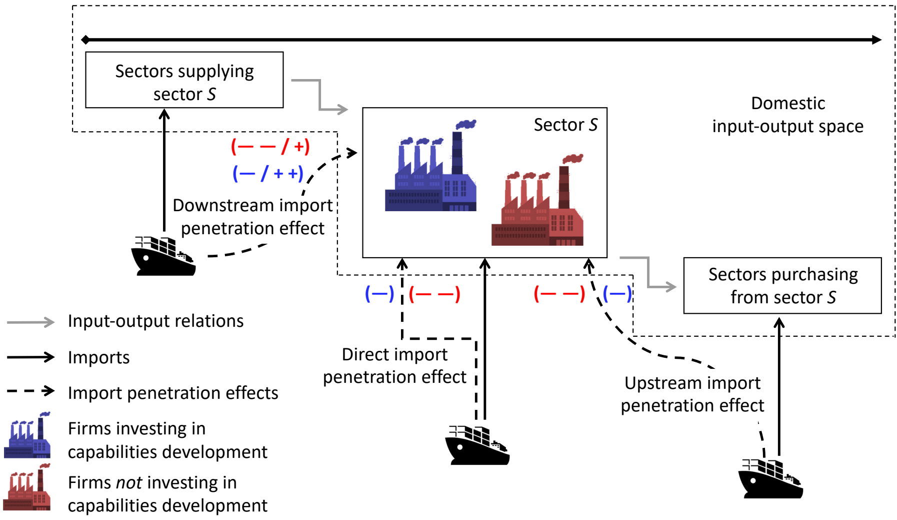
[56] A potential shortcoming of this identification strategy is presented and discussed in Section 3.5.4.

These expected results are summarised and graphically represented in Figure 3.3, which points to the existence of both direct and indirect channels through which import penetration might affect a firm's growth dynamics in employment and sales, and the likelihood of its exit from the market. The scheme represented below also underlines that mediating factors related to investments in capabilities development might lead to disproportional dynamics and heterogeneous effects across firms.

Figure 3.3. The impact of direct and indirect Chinese import penetration on South Africa-based firms.



Notes: Plus and minus symbols indicate expected signs of the impact of direct and indirect Chinese import penetration effects. Their colours (blue or red) refer to the sub-set of firms affected (those that invest intensively in capabilities development and those that do not, respectively). Single or double plus and minus symbols refer to the expected relative magnitude of these effects.
Source: Own elaboration.

3.4 Descriptive analysis

In this section, a preliminary descriptive analysis is conducted. It focuses on (3.4.1) the key trends of Chinese competitive pressure in South African manufacturing in the aftermath of the GFC; (3.4.2) the relationship between the average annual change in Chinese import penetration and the average industry-level investment intensity in capabilities development and accumulation; and (3.4.3) the main traits of the population of South Africa-based manufacturing firms, focusing on patterns of investment intensity in capabilities development.

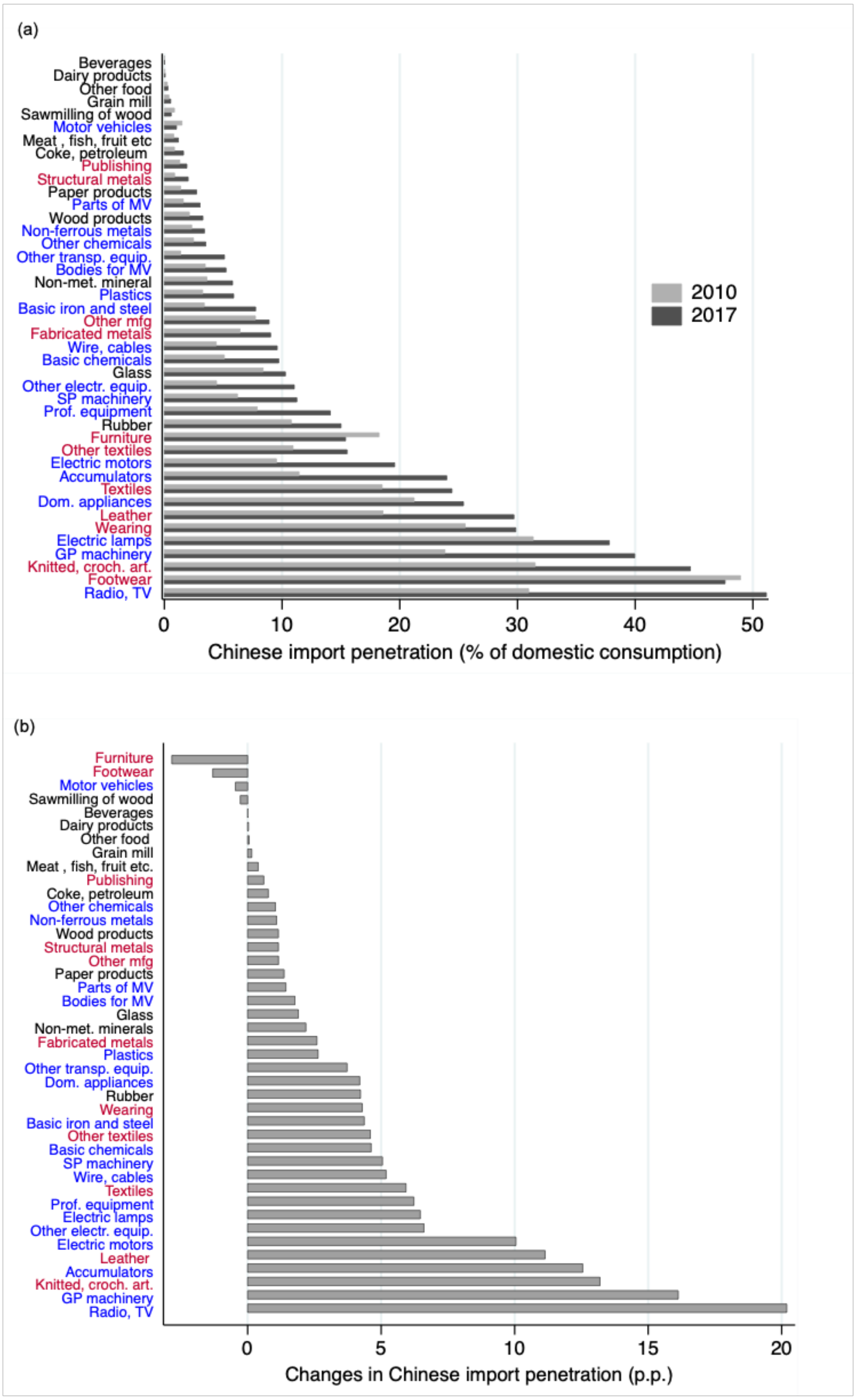
3.4.1 Chinese import penetration in the South African manufacturing sector

Figure 3.4 shows the levels (a) and the changes (b) of Chinese import penetration in the South African manufacturing industries for the 2010–2017 period. Sectors are grouped by technological categories on the basis of the classification proposed by Lall (2000) and reported in Table A.1 in Appendix A.[57] As Figure 3.4 shows, while in 2017 China still represented a major source of imports in the traditional low-technology and labour-intensive sectors such as textiles and clothing, during the 2010–2017 period its dominance shifted to MHT sectors such as electronics, non-electrical machinery, and professional and scientific instruments.[58]

[57] I believe that this classification is better suited to a country such as South Africa than the one proposed by Hatzichronoglou (1997) and used by the OECD, which is based on direct R&D intensity and R&D embodied in intermediate and investment goods in a subset of advanced countries. Unfortunately, due to the specific industry classification used here, I am not able to distinguish between medium- and high-technology sectors, so I aggregated them within a single category.

[58] Table A.2 in Appendix A reports detailed information on the percentage of Chinese imports in total South African imports and in total domestic consumption by manufacturing sub-sectors, in 2010 and 2017.

Figure 3.4. Levels and changes of Chinese import penetration across South African manufacturing sectors, 2010–2017.



Notes: Colours represent resource-based (black), low-technology (red) and medium- and high-technology (blue) industries, respectively, according to Lall (2000).
Source: Own calculations using UN Comtrade (2018) and Statistics South Africa (2018b).

Table 3.2 reports import penetration ratios from China, from other low-wage countries, $PEN_{s,t}^{LOW}$, defined as economies with per-capita income lower than 15% of the US per capita income,[59] and from the rest of the world, $PEN_{s,t}^{ROW}$ (i.e., mainly upper-middle- and high-income economies).[60] In particular, the comparison between Chinese and other low-wage countries' import penetration over the period 2010–2017 qualifies China as a special case within the subset of low-income economies. Indeed, the level of China's share in South African total domestic consumption for most MHT products, such as general and special purpose machinery, and electronics, is significantly higher than import penetrations from other low-wage economies (the only exceptions are other chemicals, non-ferrous metals and motor vehicles).

The negligible relevance of imports from other low-wage countries in such sectors also contrasts with the magnitude observed in import penetration from the rest of the world (i.e., mainly upper-middle- and high-income countries). This evidence might suggest the existence of two relatively distinct market segments across different manufacturing sectors: the first mostly monopolised by the presumably cheaper, less sophisticated and more standardised Chinese products; and the second dominated by the high-end goods shipped from advanced economies (e.g., mainly from Germany, Japan, the United States, Italy and Korea). Nonetheless, in some such sectors import penetration from the rest of the world decreased between 2010 and 2017 (e.g., by 23.38 percentage points for TV, radio and other communication apparatus, and by 9.30 and 2.99 percentage points for general and special purpose machinery, respectively). This evidence suggests that in these industries the increase in Chinese import penetration has also come at the expense of imports from other countries, especially upper-middle- and high-income ones.

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[59] Bernard et al. (2006), and Alvarez and Claro (2009), employed a lower income threshold (5% of the US per-capita income). However, their studies were restricted to the pre-2000 period when China's per-capita GDP was below the threshold of 5%, increasing from 1.4% of the US per-capita GDP in 1990 to 3.6% in 2000. Since this analysis focuses on the 2010–2017 period, I raise the income threshold in order to make a more accurate comparison with other LMICs, taking into account the enormous progress on economic and living standards made by China during the last two decades. During the period of interest in this chapter, China's per-capita GDP was below the threshold of 15%, increasing from 9.4% of the US per-capita GDP in 2010 to 13.8% in 2017. Table A.3 in Appendix A provides a list of the countries that are classified as low-wage countries in all years of the sample (excluding China).

[60] Such variables are computed following the formula in Equation 3.1, substituting the numerator with $M_{s,t}^{LOW}$ and $M_{s,t}^{ROW}$, respectively.

Table 3.2. Percentage of imports in total South African domestic consumption by origin, 2010–2017.

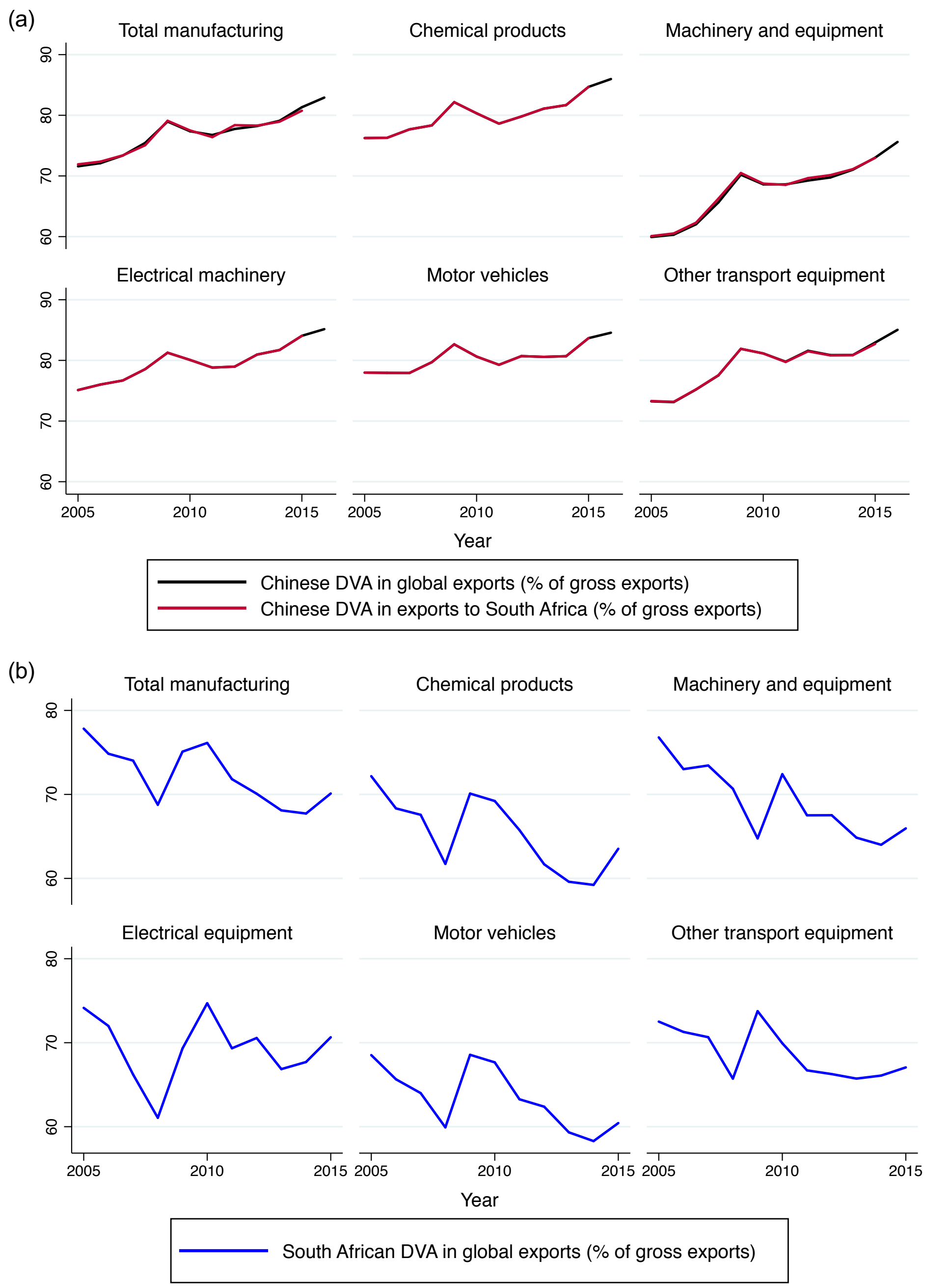
		China		Other low-wage countries		Rest of the world	
Code	Description	2010	2017	2010	2017	2010	2017
	Resource-based						
301	Meat, fish, fruit, etc.	0.79	1.18	5.99	5.59	14.02	13.71
302	Dairy products	0.04	0.06	0.12	0.17	3.98	6.34
303	Grain mill prod., animal feeds	0.38	0.53	7.27	9.47	2.36	4.05
304	Other food products	0.24	0.30	3.92	4.63	5.22	8.59
305	Beverages	0.01	0.01	1.29	0.70	4.29	4.91
321	Sawmilling, planing of wood	0.85	0.57	5.89	10.45	11.58	8.32
322	Wood, wood products	2.12	3.27	1.20	2.03	5.47	7.46
323	Paper, paper products	1.37	2.74	1.97	1.75	13.21	16.90
331/2	Coke oven, petroleum products	0.85	1.62	7.40	9.08	22.00	27.74
337	Rubber products	10.78	15.00	3.94	6.32	32.07	34.31
341	Glass, glass products	8.38	10.28	2.27	2.20	11.55	14.64
342	Non-metallic mineral products	3.61	5.79	0.92	1.54	10.03	10.76
	Low-tech						
311	Spinning, weaving of textiles	18.50	24.42	14.47	19.54	10.57	9.45
312	Other textiles	10.93	15.52	6.43	10.46	12.21	16.57
313	Knitted, crocheted fabrics	31.50	44.69	9.91	26.28	12.71	13.73
314/5	Clothing	25.56	29.85	8.82	21.23	7.16	5.87
316	Leather, leather products	18.56	29.70	6.50	9.89	13.81	10.79
317	Footwear	48.93	47.63	12.13	24.17	5.24	6.31
324/5/6	Publishing, printing, rel. serv.	1.30	1.91	0.55	2.11	5.20	9.69
354	Structural steel products	0.86	2.02	0.67	0.87	5.15	3.71
355	Other fabricated metal products	6.43	9.02	2.05	2.42	11.78	12.56
391	Furniture	18.23	15.39	4.52	5.15	15.60	13.61
392	Other manufacturing	7.74	8.89	2.10	3.72	6.33	7.99
	Medium- to high-tech						
334	Basic chemicals	5.09	9.71	7.65	5.58	32.24	35.32
335/6	Other chemicals	2.47	3.51	4.48	9.48	33.53	33.39
338	Plastic products	3.25	5.88	1.96	2.31	9.77	15.05
351	Basic iron, steel	3.38	7.75	2.39	2.90	15.03	14.27
352	Non-ferrous metals	2.32	3.40	4.16	4.20	18.67	18.22
356/9	General-purpose machinery	23.83	39.96	3.50	10.61	65.69	56.39
357	Special-purpose machinery	6.20	11.25	1.95	3.87	48.66	45.67
358	Household appliance	21.21	25.41	1.96	1.90	11.24	13.16
361/2	Electrical equip., apparatus	9.52	19.56	4.10	4.32	40.46	44.77
363	Insulated wire, cable	4.39	9.58	3.53	2.12	10.67	14.10
364	Accumulators, batteries	11.44	23.99	1.96	3.57	28.01	27.72
365	Electric lamps, lighting equip.	31.33	37.80	2.69	2.38	18.99	18.03
366	Other electrical equipment	4.43	11.03	3.27	9.33	18.63	21.33
371/2/3	TV, radio, other electronic equip.	30.95	51.14	15.90	9.32	39.91	16.53
374/5/6	Medical, measuring, controlling equip.	7.88	14.10	2.48	3.77	72.45	76.98
381	Motor vehicles	1.49	1.02	4.91	12.56	43.61	48.74
382	Bodies for motor vehicles	3.47	5.24	0.26	0.77	7.08	11.38
383	Parts, accessories for motor vehicles	1.61	3.04	1.23	2.21	15.99	17.53
384/5/6/7	Other transport equipment	1.38	5.10	0.58	0.91	41.18	43.16
–	Total	5.26	8.30	4.32	6.56	23.45	25.08

Source: Own calculations using UN Comtrade (2018) and Statistics South Africa (2018b) data.

The evidence presented in Figure 3.4 and Table 3.2 captures the structural transition of China increasingly specialising in the export of medium- to high-tech products and some industrial raw materials (e.g., steel) to South Africa. As already underlined by Rodrik (2006) and Schott et al. (2008), Chinese exports seem to be more sophisticated and to show more overlap with OECD countries' products compared to those of other low-wage economies. However, one might point out that the huge quantities of Chinese exports in medium- to high-technology products, such as electronics, should not be interpreted as evidence per se that Chinese firms are able to compete in skills-intensive, high-technology sectors. For example, Branstetter and Lardy (2006) argue that most of the exported electronics and information technologies are not manufactured by Chinese firms, but by foreign firms that use China merely as a parts assembler and exports platform within GVCs. Although this might still have been the case in the early 2000s when Branstetter and Lardy were writing, it has now become clear that, during the last two decades, China has upgraded its position within GVCs towards higher value added activities (Tassey, 2014; Zhou et al., 2016, Lee et al., 2018).

As already underlined at the end of Section 3.1.2, due to data limitations, I am not able to derive import penetration variables from trade in value added data and to use them in the following regression analyses. However, trade in value added information from the 2018 release of the OECD-TiVA database (OECD-TiVA, 2018) is used here for descriptive purposes, namely, to show that the relative increase of MHT products imported by South Africa from China has also been accompanied by an increase in its domestic (i.e., China's) value added content. In fact, Figure 3.5 shows that the domestic value added (DVA) of Chinese exports in total manufacturing and in selected MHT sub-sectors, shipped to the world and specifically to South Africa, has experienced constant growth since 2005 (Figure 3.5, panel a). The dramatic technological upgrading of Chinese firms and their increasing value-addition capabilities appear to have changed the nature of Chinese competitive pressure on firms in low- and middle-income countries (Paus, 2019; Andreoni and Tregenna, 2020). The transition of Chinese firms from exporting low-technology products (e.g., textiles) to exporting medium-to high-technology products (e.g., machine tools), and from assemblers to producers and system integrators of components, might have reduced the room for manoeuvre of firms in countries like South Africa to upgrade and compete in more technologically sophisticated segments of GVCs. This conjecture seems to be supported by the declining trends in DVA content of South African exports. In fact, Figure 3.5 shows that between 2005 and 2015 South Africa experienced an erosion of DVA embodied in exports of total manufacturing and in the same selected MHT sub-sectors (Figure 3.5, panel b).

Figure 3.5. Trends in Chinese (a) and South African (b) DVA content of exports by sector, 2005–2016/2015.

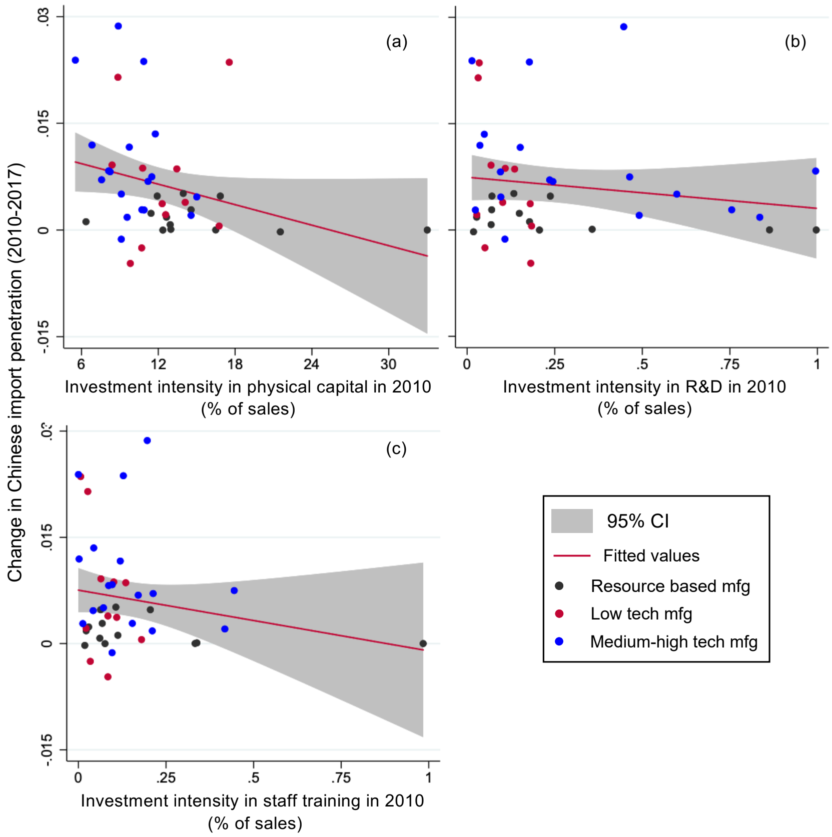


Notes: Panel (a): Chinese DVA content of global exports as a percentage of global gross exports between 2005 and 2016 (black line); Chinese DVA content of exports to South Africa as a percentage of gross exports to South Africa between 2005 and 2015 (red line). Bilateral data is not available after 2015. Panel (b): South African DVA content of global exports as a percentage of global gross exports between 2005 and 2015 (blue line). Data for South Africa is not available after 2015.
Source: Own calculations using OECD-TiVA (2018).

3.4.2 Changes in Chinese import penetration and the average industry-level investment intensity in capabilities development

Figure 3.6 sheds some light on the relationship between the average annual change in Chinese import penetration between 2010 and 2017 and the average industry-level intensity in investments in process, product and skills development across South African manufacturing sectors in 2010. According to this, the larger increase in imports from China is concentrated in industries with lower investment intensity in capabilities development. This negative relationship is much weaker and not statistically significant in the case of investment intensity in R&D (b) and staff training (c).

Figure 3.6. Average annual change in Chinese import penetration over 2010-2017 and average industry-level investment intensity in capabilities development in 2010.



Notes: Each point represents a manufacturing industry (N = 42). Lines are fitted by OLS regression. The 95% confidence interval is based on robust standard errors. In (a), the slope coefficient is –0.007 with robust standard errors 0.002 and t-statistic –3.19. In (b), the slope coefficient is –0.004 with robust standard errors 0.002 and t-statistic –1.32. In (c), the slope coefficient is –0.0005 with robust standard errors 0.0002 and t-statistic –2.10.
Source: Own calculations using UN Comtrade (2018) and SARS data.

Interestingly enough, the pattern of average industry-level investment intensity in R&D (Figure 3.6, panel b) emerging from the analysis of the firm-level data seems to be only partly in line with the technological categories developed by Lall (2000). Some MHT sectors, such as machinery for general purposes, plastic products and consumer electronics sectors, display extremely low levels of investment intensity in R&D in the South African case.

3.4.3 Capabilities and growth dynamics: a portrait of South Africa-based manufacturing firms

On average, for the 2010–2017 period, approximately 64% of manufacturing firms registered in South Africa reported positive investment in capital equipment, while only 10% spent on training and only 5% on R&D. In terms of intensity, during the same period manufacturing firms spent on average around 5% of their total turnover on capital investment, and only 0.08% and 0.13% on training and R&D activities, respectively (see also Table 3.1 on this).[61]

However, there is a high degree of heterogeneity among firms of different sizes and sectors in terms of both the average share of firms' spending in such activities and assets, and the average intensity of these investments. Overall, firms in resource-based and MHT sectors outperform the investments in capabilities development of firms in low-technology sectors, especially with respect to R&D and training efforts, both in terms of the average share of investors and the average investment intensity (see Table A.4 in Appendix A for further details on this). Furthermore, more of the medium and especially large firms spend greater shares of their turnover on R&D and personnel training activities when compared to smaller firms (see Table A.5 in Appendix A for further details on this).

Table 3.3 reports evidence suggestive of the superior performance of firms investing in one or more activities related to capabilities development when compared to firms not investing in any of these during the 2010–2017 period.[62] According to the evidence shown in Table 3.3, the average employment growth, sales growth and survival rate of manufacturing firms investing in capabilities development activities have been substantially larger (19.55%, 11.77% and 98.63%) than that experienced by firms not undertaking any capabilities development investment (6.62%, 7.79% and 94.07%).

[61] Previous research employing an earlier version of the firm-level SARS database also found that R&D intensity in South Africa-based manufacturing firms is considerably lower than that observed in studies on other countries (Steenkamp et al., 2018).
[62] In Table 3.3, the firms investing in capabilities development are firms reporting positive expenditures in year *t* in any of the following: capital investments, R&D expenditures, spending on staff training.

Table 3.3. Growth dynamics of firms investing in capabilities development versus non-investing ones.

Variable	Class of firms	2010–2017 (%)
Average employment growth	All firms	15.55
	Firms not investing in capabilities development	6.62
	Firms investing in capabilities development	19.55
Average sales growth	All firms	5.39
	Firms not investing in capabilities development	–7.79
	Firms investing in capabilities development	11.77
Average exit rate	All firms	3.14
	Firms not investing in capabilities development	5.93
	Firms investing in capabilities development	1.37

Notes: The firms investing in capabilities development are those firms reporting positive expenditures in year *t* in any of the following: capital investments, R&D expenditures, spending on staff training.
Source: Own calculations using SARS data.

3.5 Econometric results

In this section, I report the main econometric results of this empirical investigation. First, I present baseline estimates of the impact of direct Chinese import penetration on three measures of firm growth (i.e., employment growth, sales growth, firm exit), taking into account firm heterogeneity in terms of relative investments in process and product innovation, and in skills development. Second, I expand the baseline analysis to take into account the impact of indirect Chinese import penetration, propagating through intersectoral linkages along the domestic value chain. Finally, I provide some robustness checks and extensions.

3.5.1 Direct effects of Chinese import penetration

3.5.1.1 Employment growth

I first test the hypothesis that employment growth for surviving firms decreases with Chinese import penetration. I also explore whether this impact is smaller, within industries, for firms investing more intensively in product and process innovation, and skills development. Results are shown in Table 3.4. Columns 1 and 2 report the OLS estimates. The former refers to the baseline specification, including the main variable of interest, $PEN_{s,t}^{CHN}$. In the latter I add interaction terms between Chinese import penetration and a battery of dummies taking the value 1 for firms intensively investing in physical capital, R&D and staff training. Columns 3 and 4 report the corresponding IV estimates.

As far as firm-level controls are concerned, all variables apart from firm age and training intensity are significant and exhibit the expected signs. I find that firms with smaller size and relatively high investment intensity in physical capital grow faster in terms of employment. Furthermore, employment growth is higher for firms investing more intensively in R&D.[63] Interestingly, and in contrast with most of the literature, I find that, in the South African manufacturing sector, firm age positively influences employment growth.[64]

Estimation results on the impact of import-exposure variables in all specifications reveal that employment growth is significantly and negatively related to direct import penetration from China. As expected, the magnitudes of the coefficient of $PEN_{s,t}^{CHN}$ are higher in the IV specifications with respect to the OLS figures.

Taking the coefficient value corresponding to the entire sample of South Africa-based manufacturing firms, in the third column I find that a one-standard-deviation increase in Chinese import penetration (equal to 9.7 percentage points) for the mean firm is associated with a decrease in annual firm employment growth of 12.9 percentage points. However, the implied growth magnitudes of the coefficients are quite small in absolute terms, albeit still higher than other similar studies for developed countries (Mion and Zhu, 2013). Indeed, considering that the average across firms of Chinese import penetration has steadily increased from 0.0752 to 0.1073 over the 2010–2017 period across the entire sample, the estimates indicate that the rise in import competition from China accounts for a 4.28% loss in manufacturing-wide firm employment growth.[65]

Results in columns 2 and 4 further qualify the baseline OLS and IV findings, respectively. The interactions of $PEN_{s,t}^{CHN}$ with the dummy variables on firm-level investments in physical capital, R&D and staff training indicate that Chinese imports are inducing a within-industry reallocation of resources across firms characterised by different intensities in terms of such investments. Specifically, all of the interaction terms in columns 2 and 4

[63] At the microeconomic level, the empirical literature has generally found a positive employment effect of product innovation. Conversely, the impact on employment of process innovation is more controversial: it might be directly negative due to a job-saving effect under fixed output, but also indirectly positive mainly due to a price compensation mechanism boosting output expansion (Calvino and Virgillito, 2017).

[64] Some exceptions have been found to the widely documented evidence that younger firms grow faster in terms of size than older firms. For example, Shanmugam and Bhaduri (2002) showed that employment growth is faster for older Indian manufacturing firms. Das (1995), again with reference to India, reported a positive effect of firm age on employment growth in the computer hardware industry.

[65] The effect of the increase in Chinese import penetration over the period under analysis is given by the following formula: $-1.333 \times (0.1073 - 0.0752) = -0.0428$.

are significant and positive, revealing that, within industries, firms that invest relatively more intensively in capabilities development tend to be hit less hard by Chinese import penetration than other firms.

Using the point estimates in column 4, I find that investing in physical capital, R&D and staff training reduces the negative effect of a one-standard-deviation increase in Chinese import competition on firm employment growth by 2.2, 1.3 and 1.4 percentage points, respectively. Thus, moving from below- to above-median investment intensity in activities related to capability development reduces the effect of import competition by only one-sixth (in the case of investments in physical capital) and one-tenth (in the case of expenditures in R&D, and of spending on training) of the average effect.

3.5.1.2 Sales growth

I employ the same specifications structure used in Table 3.4 to study whether Chinese import penetration has generated a negative impact on output dynamics of surviving firms. I also explore whether this impact is smaller for firms investing intensively in product and process innovation, and skills development.

As in the case with employment growth, in Table 3.5 I find that smaller and older firms report higher output growth. Furthermore, sales growth is higher for firms intensively investing in physical capital, while I find no significant relationship between output growth and investments in R&D and staff training.

Estimation results in all specifications reveal that Chinese import competition negatively and significantly affects the output growth of surviving firms. Coefficient estimates in column 3 indicate that a one-standard-deviation increase in Chinese import penetration for the mean firm is associated with a 13.2% decrease in annual firm employment growth. The implied growth magnitude of the coefficient shows that the increase in import competition from China between 2010 and 2017 accounts for a 4.39% loss in manufacturing-wide firm sales growth.

The results on the capital investment, R&D and training interactions with $PEN_{s,t}^{CHN}$ indicate that firms investing more intensively in physical capital and R&D are hit slightly less hard by such competitive pressure. Using the point estimates in column 4, I find that firms investing in physical capital and R&D activities reduce the negative effect of a one-standard-deviation increase in Chinese import competition on sales growth by 2.4 and 1.3 percentage points, respectively.

3.5.1.3 Firm exit

Table 3.6 reports estimates on the relationship between import competition and the probability of firm death. The structure of the different specifications presented is the same as for employment and sales growth.

The results in Table 3.6 are fairly consistent with previous empirical evidence for size and age. Firm shutdown is negatively associated with firm size, while the coefficient for firm age is positive and significant. This latter finding, in contrast to learning models (Jovanovic, 1982), but consistent with previous evidence on Chilean plants (Alvarez and Claro, 2009), suggests that older firms are more likely to die. Finally, higher investment intensity in physical capital reduces the probability of exit in all the specifications, while the impacts of investment intensity in R&D and in staff training are never significant.

The coefficient value of Chinese import penetration, corresponding to the entire sample of South Africa-based manufacturing firms in columns 1 and 3, reveals that increasing competitive pressure from China does not significantly affect the likelihood of firm shutdown. However, when considering interactions with firm-level investments in capabilities development, in columns 2 and 4, it turns out to be significant and positive. IV results in column 4 indicate that a one-standard-deviation increase in Chinese import penetration for the mean firm not investing intensively in any capabilities development activity is associated with a 3.6% increase in the probability of death. According to the estimates in column 4, the increase in Chinese import penetration between 2010 and 2017 has caused a 1% increase in the shutdown probability for firms not undertaking significant investment in capabilities development. The evidence reported in Table 3.6 is in line with most of the results of similar studies, which find a positive and significant impact of import penetration from low-wage countries in general, particularly from China, both in developed (Bernard et al., 2006) and developing (Alvarez and Claro, 2009) countries.[66]

The results of the interactions of $PEN_{s,t}^{CHN}$ with the dummies of interests indicate that firms investing more intensively in capabilities development have a lower probability of exiting the market in light of increasing Chinese import penetration. All of the interaction

[66] Contrary to these results, Mion and Zhu (2013) found that Chinese import penetration had no significant impact on the probability of exit for Belgian manufacturing firms over the period 1996–2007.

terms in columns 2–4 are significant and negative, revealing that investing in capital equipment, R&D activities and staff training reduces the negative effect of a one-standard-deviation increase in Chinese import competition on the probability of firm shutdown by 2.5, 0.5 and 2 percentage points, respectively. Thus, moving from below- to above-median investment intensity in physical capital and staff training reduces the effect of import competition by over two-thirds and by over half of the average effect, respectively, while relatively larger R&D spending is found to diminish such impact only by one-seventh of the average effect.

Table 3.4. Direct import competition analysis: employment growth.

Dep. variable	$\Delta\log(E)_{i,s}^{t,t+1}$			
Specification	(1)	(2)	(3)	(4)
Estimation method	OLS	OLS	IV	IV
Controls				
$\log(E)_{i,t}$	–0.393***	–0.395***	–0.394***	–0.396***
	(0.006)	(0.006)	(0.006)	(0.006)
$\log(Age)_{i,t}$	0.076***	0.075***	0.074***	0.073***
	(0.014)	(0.014)	(0.014)	(0.014)
$INVST_{i,t}$	0.004***	0.004***	0.004***	0.004***
	(0.002)	(0.002)	(0.002)	(0.002)
$R\&D_{i,t}$	0.001***	0.001***	0.001***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)
$TRAIN_{i,t}$	–0.001	–0.001	–0.001	–0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Import exposure variables				
$PEN_{s,t}^{CHN}$	–0.695***	–0.738***	–1.333***	–1.489***
	(0.163)	(0.237)	(0.401)	(0.401)
$\times (d)\ INVST_{i,t}$		0.341***		0.230***
		(0.051)		(0.023)
$\times (d)\ R\&D_{i,t}$		0.166**		0.150**
		(0.068)		(0.075)
$\times (d)\ TRAIN_{i,t}$		0.084**		0.149**
		(0.026)		(0.034)
Constant	0.962***	0.958***	1.058***	1.064***
	(0.039)	(0.039)	(0.036)	(0.036)
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
First-stage F-stat.	-	-	666.20	562.69
Observations	90,530	90,530	90,530	90,530
R-squared	0.3206	0.3214	0.3157	0.3162
Number of firms	12,959	12,959	12,959	12,959

1. Dependent variable is log difference of firm employment between year t and $t + 1$.
2. All estimates refer to the subset of surviving firms.
3. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in columns 3 and 4.
4. The instrumental variable is interacted with the dummies in column 4.
5. Standard errors in parentheses are clustered at both the industry and firm level.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Own calculations using SARS data.

Table 3.5. Direct import competition analysis: sales growth.

Dep. variable	$\Delta\log(S)_{i,s}^{t,t+1}$			
Specification	(1)	(2)	(3)	(4)
Estimation method	OLS	OLS	IV	IV
Controls				
$\log(E)_{i,t}$	–0.364***	–0.364***	–0.365***	–0.364***
	(0.010)	(0.010)	(0.010)	(0.010)
$\log(Age)_{i,t}$	0.061***	0.060***	0.058***	0.059***
	(0.014)	(0.014)	(0.014)	(0.014)
$INVST_{i,t}$	0.001***	0.001***	0.001***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)
$R\&D_{i,t}$	0.003	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
$TRAIN_{i,t}$	–0.001	–0.001	–0.001	–0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Import exposure variables				
$PEN_{s,t}^{CHN}$	–0.817***	–0.922***	–1.367***	–1.404***
	(0.254)	(0.273)	(0.415)	(0.415)
$\times (d)\ INVST_{i,t}$		0.172***		0.232***
		(0.061)		(0.022)
$\times (d)\ R\&D_{i,t}$		0.102**		0.115**
		(0.068)		(0.054)
$\times (d)\ TRAIN_{i,t}$		–0.099		0.055
		(0.076)		(0.038)
Constant	5.749***	5.675***	5.860***	5.879***
	(0.155)	(0.154)	(0.158)	(0.160)
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
First-stage *F*-stat.	-	-	635.86	547.64
Observations	86,289	86,289	86,289	86,289
R-squared	0.2242	0.2242	0.2196	0.2198
Number of firms	12,919	12,919	12,919	12,919

1. Dependent variable is log difference of firm employment between year *t* and *t + 1*.
2. All estimates refer to the subset of surviving firms.
3. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in columns 3 and 4.
4. The instrumental variable is interacted with the dummies in column 4.
5. Standard errors in parentheses are clustered at both the industry and firm level.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Own calculations using SARS data.

Table 3.6. Direct import competition analysis: firm exit.

Dep. variable	$Death_{i,s}^{t,t+1}$			
Specification	(1)	(2)	(3)	(4)
Estimation method	OLS	OLS	IV	IV
Controls				
$\log(E)_{i,t}$	–0.056***	–0.054***	–0.056***	–0.052***
	(0.002)	(0.002)	(0.002)	(0.002)
$\log(Age)_{i,t}$	0.127***	0.130***	0.127***	0.133***
	(0.006)	(0.006)	(0.006)	(0.006)
$INVST_{i,t}$	-0.002***	-0.002***	-0.002***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
$R\&D_{i,t}$	–0.001	–0.001	–0.001	–0.001
	(0.001)	(0.001)	(0.001)	(0.001)
$TRAIN_{i,t}$	–0.001	–0.001	–0.001	–0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Import exposure variables				
$PEN_{s,t}^{CHN}$	0.194	0.275**	0.204	0.370**
	(0.179)	(0.102)	(0.178)	(0.180)
$\times (d)\ INVST_{i,t}$		–0.152***		–0.255***
		(0.033)		(0.012)
$\times (d)\ R\&D_{i,t}$		–0.025**		–0.036**
		(0.018)		(0.020)
$\times (d)\ TRAIN_{i,t}$		–0.126***		–0.204***
		(0.012)		(0.015)
Constant	–0.184***	–0.186***	–0.176***	–0.196***
	(0.021)	(0.021)	(0.020)	(0.020)
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
First-stage *F*-stat.	-	-	651.10	523.76
Observations	129,695	129,695	129,695	129,695
R-squared	0.0773	0.0773	0.0753	0.0753
Number of firms	22,785	22,785	22,785	22,785

1. Dependent variable is a dummy indicating firm death in year $t + 1$.
2. A linear probability model is used in all specifications.
3. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in columns 3 and 4.
4. The instrumental variable is interacted with the dummies in column 4.
5. Standard errors in parentheses are clustered at both the industry and firm level.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Own calculations using SARS data.

3.5.2 The effects of indirect Chinese import penetration: accounting for sectoral linkages

Tables 3.7 and 3.8 report IV estimates of the impacts of Chinese import exposure on employment and sales growth, and the probability of shutdown for South Africa-based firms, analogous to those in Tables 3.4, 3.5 and 3.6, including the indirect import exposure measures. Tables A.6 and A.7 in Appendix A show the corresponding OLS estimates. Panel A refers to the effects of the first-order indirect import exposure measures and panel B employs the full Leontief variants. All specifications include the constant and all the firm-level controls used in the previous estimates in Tables 3.4 to 3.6 (unreported, to facilitate readability).

Columns 1 to 3 of Table 3.7 report the results of the impact of direct and indirect Chinese import penetration on firm employment. On the one hand, downstream import effects are negative in sign, but never statistically significant (see columns 2 and 3), consistent with the results of Acemoglu et al. (2016) and Hombert and Matray (2018). This might be explained by the fact that in the case of South Africa the increased availability of cheaper foreign imported inputs is offset by a reduction in domestic inputs supply. On the other hand, as expected, the upstream import effect has a negative and significant impact on firm employment growth. Coefficient estimates in column 1 indicate that a one-standard-deviation increase in upstream Chinese import penetration (equal to 2.6 percentage points) for the mean firm is associated with a decrease in annual firm employment growth of 7.5 percentage points.

Given the non-significance of the impact arising through downstream sectoral interdependencies, columns 4 and 5 focus on the upstream effects, regressing firm employment growth on a combined direct-upstream exposure measure, consisting of their sum. As expected, the estimated coefficient on this combined effect lies between the coefficients on the direct and upstream impacts estimated in column 1.

Furthermore, the results in column 5 indicate that firms that invest relatively intensively in physical capital, R&D and staff training are also hit less hard by the Chinese import competition pressure affecting their buyers in downstream segments of the domestic value chain. Indeed, investing relatively more intensively in physical capital, in R&D and in staff training activities reduces the negative effect of a one-standard-deviation increase in the combined direct-upstream Chinese import penetration on employment growth by 2.1, 1.3

and 1.2 percentage points, respectively. Panel B of Table 3.7 reveals a similar pattern in terms of results. Overall, in this case, the coefficients on the full exposure measures are slightly smaller in magnitude (but also more precisely estimated) than those reported in Panel A on the first-order indirect import exposure.

Table 3.8 reports the results of the impact of direct and indirect Chinese import penetration on output dynamics and the probability of shutdown of South Africa-based manufacturing firms. As for the case of employment growth, I focus on the upstream effects, regressing firm sales growth and the probability of shutdown on the sum of direct and upstream exposure measures as in columns 4 and 5 of Table 3.8.[67]

The results in columns 2 and 4 confirm that firms investing substantial resources in capabilities development grow faster in terms of sales and are less likely to shut down even in the wake of increasing competitive pressure in downstream segments of the domestic value chain. As in Table 3.5, I find that staff training expenditures have no significant impact on firm sales growth.

[67] Estimates reported in Table A.8 in Appendix A show that the effects propagating through downstream sectoral linkages are also not statistically significant in the case of sales growth and probability of exiting the market.

Table 3.7. Indirect import competition analysis: employment growth.

Dep. variable	$\Delta\log(E)_{i,s}^{t,t+1}$				
Specification	(1)	(2)	(3)	(4)	(5)
Estimation method	IV	IV	IV	IV	IV
A. First-order indirect import exposure variables					
$PEN_{s,t}^{CHN}$	–1.235***	–1.325***	–1.237***		
	(0.369)	(0.412)	(0.412)		
$PEN_{s,t}^{CHN,UP}$	–2.885***		–3.013***		
	(0.843)		(0.840)		
$PEN_{s,t}^{CHN,DOWN}$		–0.091	–0.652		
		(0.759)	(0.746)		
$PEN_{s,t}^{CHN} + PEN_{s,t}^{CHN,UP}$				–1.245***	–1.369***
				(0.373)	(0.358)
$\times\ (d)\ INVST_{i,t}$					0.208***
					(0.020)
$\times\ (d)\ R\&D_{i,t}$					0.172***
					(0.020)
$\times\ (d)\ TRAIN_{i,t}$					0.127***
					(0.030)
First-stage *F*-stat.	537.09	515.19	532.89	508.06	447.28
R-squared	0.3305	0.3298	0.3309	0.3311	0.3312
B. Full (higher-order) indirect import exposure variables					
$PEN_{s,t}^{CHN}$	–1.304***	–1.340***	–1.311***		
	(0.368)	(0.414)	(0.371)		
$PEN_{s,t}^{CHN,UP}$	–2.487***		–2.582***		
	(0.697)		(0.697)		
$PEN_{s,t}^{CHN,DOWN}$		–0.074	–0.622		
		(0.656)	(0.640)		
$PEN_{s,t}^{CHN} + PEN_{s,t}^{CHN,UP}$				–1.322***	–1.440***
				(0.362)	(0.351)
$\times\ (d)\ INVST_{i,t}$					0.202***
					(0.019)
$\times\ (d)\ R\&D_{i,t}$					0.123***
					(0.046)
$\times\ (d)\ TRAIN_{i,t}$					0.117***
					(0.028)
First-stage *F*-stat.	532.71	510.23	526.11	501.56	432.87
R-squared	0.3304	0.3297	0.3307	0.3312	0.3313
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Observations	90,530	90,530	90,530	90,530	90,530
Number of firms	12,959	12,959	12,959	12,959	12,959

1. Dependent variables are log difference of firm employment between year t and t + 1.
2. All estimates refer to the subset of surviving firms.
3. All specifications report IV estimates and include the constant and all controls used in previous estimates.
4. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in all columns.
5. The instrumental variable is interacted with the dummies in column 5.
6. Standard errors in parentheses are clustered at both the industry and firm level.

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}p < 0.01$

Source: Own calculations using SARS data.

Table 3.8. Indirect import competition analysis: sales growth and firm exit.

Dep. variable	$\Delta\log(S)_{i,s}^{t,t+1}$	$\Delta\log(S)_{i,s}^{t,t+1}$	$Death_{i,s}^{t,t+1}$	$Death_{i,s}^{t,t+1}$
Specification	(1)	(2)	(3)	(4)
Estimation method	IV	IV	IV	IV
A. First-order indirect import exposure variables				
$PEN_{s,t}^{CHN} + PEN_{s,t}^{CHN,UP}$	–1.053***	–1.079***	0.174	0.307**
	(0.368)	(0.369)	(0.160)	(0.153)
$\times (d)\ INVST_{i,t}$		0.045***		–0.222***
		(0.022)		(0.010)
$\times (d)\ R\&D_{i,t}$		0.108***		–0.029**
		(0.051)		(0.017)
$\times (d)\ TRAIN_{i,t}$		0.042		–0.176***
		(0.032)		(0.013)
First-stage *F*-stat.	545.16	429.45	569.15	413.71
R-squared	0.2086	0.2088	0.0721	0.0722
B. Full (higher-order) indirect import exposure variables				
$PEN_{s,t}^{CHN} + PEN_{s,t}^{CHN,UP}$	–1.023***	–1.047***	0.169	0.296**
	(0.383)	(0.383)	(0.165)	(0.164)
$\times (d)\ INVST_{i,t}$		0.044***		–0.214***
		(0.021)		(0.010)
$\times (d)\ R\&D_{i,t}$		0.105***		–0.027**
		(0.049)		(0.017)
$\times (d)\ TRAIN_{i,t}$		0.042		–0.169***
		(0.031)		(0.012)
First-stage *F*-stat.	532.09	417.35	540.87	409.12
R-squared	0.2087	0.2090	0.0723	0.0724
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Observations	86,289	86,289	129,695	129,695
Number of firms	12,919	12,919	22,785	22,785

1. Dependent variables in (1) and (2) is log difference of firm sales between year t and t + 1.
2. Dependent variables in (3) and (4) is a dummy indicating firm death in year t + 1.
3. A linear probability model is used in (3) and (4).
4. Estimates in (1) and (2) refer to the subset of surviving firms.
5. All specifications include the constant and all controls used in previous estimates.
6. All specifications report IV estimates.
7. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in all columns.
8. The instrumental variable is interacted with the dummies in columns 2 and 4.
9. Standard errors in parentheses are clustered at both the industry and firm level.

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}p < 0.01$

Source: Own calculations using SARS data.

3.5.3 Robustness checks and additional findings

As a first robustness check, in some additional estimates I also replicate the analysis of firms' employment and sales growth on the full sample, including companies dying during the period under analysis. Table A.9 in Appendix A reports the IV results of the direct import competition analysis on firms' employment and sales growth for the full sample. I obtain very similar estimates for the full sample and for the subset of survivors (see specifications 3 and 4 of Tables 3.4 and 3.5 above).

Second, following Alvarez and Claro (2009), I also replicate all the estimates including a set of province dummy variables to control for potential shocks to specific locations over time. The results of the direct import competition analysis on firm survival and growth are reported in Table A.10 in Appendix A. They remain quantitatively and qualitatively the same.

Third, in some additional estimates I also control for import penetration from other low-wage countries, $PEN_{s,t}^{LOW}$, defined as economies with per-capita income lower than 15% of the US per capita income,[68] and from the rest of the world, $PEN_{s,t}^{ROW}$ (mainly upper-middle- and high-income economies). Such variables are computed following the formula in Equation 3.1, substituting the numerator with $M_{s,t}^{LOW}$ and $M_{s,t}^{ROW}$, respectively. This counterfactual exercise allows the specific effect of Chinese import competition, which constitutes the main variable of interest, to be better identified. Table A.11 of Appendix A reports the IV results of the direct import competition analysis on employment growth, sales growth and firm exit, including import penetration from other low-wage countries and from the rest of the world. The results of these estimates indicate that import competition from China has a similar effect, albeit of larger magnitude, to import competition from upper-middle- and high-income economies, and I find no significant impact of imports from other low-wage countries. This finding confirms the evidence that Chinese exports seem to be more sophisticated and show more overlap with OECD countries' products with respect to other low-wage countries (Rodrik, 2006; Schott et al., 2008).

Fourth, to examine further the role of spending intensity in product innovation activities, I replicate the analysis using as covariates two additional measures in place of $R\&D_{i,t}$. First, as a proxy of expenditure intensity in external product innovation, I include in the regression

[68] Table A.3 in Appendix A provides a list of the countries that are classified as low-wage countries in all years of the sample (excluding China). For further details on how these countries were identified and selected see footnote 59 in Section 3.4 of this chapter.

analysis firms' spending intensity in royalties and patent rights, $ROYAL_{i,t}$. Second, I substitute this variable with a measure of the intensity of the total expenditures in innovation-related activities (i.e., a composite index obtained by the sum of expenditures in R&D, and royalties and patent rights, normalised by total sales), $INNOV_{i,t}$. Table A.12 and A.13 report the IV results of the direct import competition analysis on employment growth, sales growth and firm exit, including $ROYAL_{i,t}$ and $INNOV_{i,t}$ as covariates in place of $R\&D_{i,t}$. From a comparison of these additional estimates with the results in column 4 for Tables 3.4 to 3.6, it seems that the role of firms' expenditures in product innovation in mitigating the negative Chinese import penetration effect on their growth dynamics is mainly driven by expenditure intensity in internal (i.e., $R\&D_{i,t}$) rather than external (i.e., $ROYAL_{i,t}$) product innovation.

Finally, in an additional robustness exercise, I try to solve a key issue arising from the instrumental variable strategy adopted in this chapter. In fact, as pointed out by Autor et al. (2013), in some sectors import demand shocks might correlate across less developed countries. In this case, IV estimates of the coefficient of Chinese import penetration might likely be biased, appearing smaller than they truly are in the case of firms' employment and sales growth, and death. Following Autor et al. (2013), I address this problem by excluding from the measure of import competition and from the corresponding IV those industries that may give rise to these issues, such as consumer electronics (i.e., accumulators and batteries, electric lamps, communication electronic equipment, domestic appliances, etc.).[69] Table A.14 of Appendix A reports the results of this additional exercise on the direct Chinese import competition effect on the growth and survival dynamics of South Africa-based companies. These estimates confirm the overall validity of the IV approach and, in fact, the coefficient of the variable of interest remains qualitatively and quantitatively the same: the impact of Chinese import competition becomes only slightly larger when excluding consumer electronics industries from the measure of imports.

3.6 Conclusions

In this chapter I have employed a unique firm-level database made available by SARS to analyse the impact of Chinese import penetration in manufacturing industries on the growth dynamics

[69] As pointed out by Autor et al. (2013), in such sectors the increase of Chinese imports both to South Africa and other developing economies might be driven by a combination of rising domestic demand (for mobile phones, for example), and growing Chinese productivity and manufacturing capacity (so parts and components for mobile phones are sourced from Chinese suppliers rather than, say, Japanese or South Korean companies). For these industries, even employing the instrumental approach introduced in Section 3.3.2.1, I might fail to capture the real effect that rising Chinese imports would have on South Africa-based manufacturing firms.

of South Africa-based manufacturing firms from 2010 to 2017. I have produced new evidence on both the heterogeneous nature of this impact and the way it spreads through linkages along domestic value chains. Due to possible endogeneity and reverse causality issues, I have instrumented Chinese import penetration using China's share in other LMICs' imports.

Econometric results indicate that rising direct Chinese import exposure has negatively affected the employment and sales growth of surviving firms, and it has increased the probability of shutdown for the subset of companies not investing intensively in capabilities development. The implied growth magnitude of such effects is relatively high compared to other similar studies for advanced economies (Mion and Zhu, 2013). According to the estimates, the increase in direct Chinese import penetration between 2010 and 2017 accounts for approximately 4.28% and 4.39% of the loss in manufacturing-wide firm employment growth and sales growth in South Africa, respectively, and has caused a 1% increase in the shutdown probability for firms not undertaking significant investments in physical capital, R&D and staff training programmes.

Upstream import effects – originating in downstream segments of the domestic value chain and propagating upstream to supplying sectors – contribute to reduced firm employment, sales growth and survival rates. Thus, an increase in Chinese import penetration in a given industry has a negative impact on the performance of firms supplying intermediate inputs to the affected sector. Conversely, downstream import effects are never statistically significant. This might be explained by the fact that, in the South African case, the positive effect of increased availability of cheaper foreign imports is offset by the disruption of existing long-term supply relations for specialised domestic inputs (as an example, South Africa-based suppliers might reduce shipments in light of higher import competition). Thus, at least on average, I cannot detect any significant effects of firms responding to the supply of cheaper foreign inputs by expanding employment and production.

As far as heterogeneity is concerned, I find that these negative effects are smaller for firms investing intensively in capabilities development, specifically in process and product innovation, and in skills development programmes. In almost all estimates, the interaction terms between the Chinese import penetration variable and binary indicators identifying firms investing intensively in capabilities development have significant and positive impacts (negative, in the case of firms' exit), revealing that firms devoting substantial resources to these activities are relatively more resilient to such competitive pressure. However, such effects are rather weak and unable to counterbalance the negative impact of Chinese import penetration.

These findings have important policy implications. Since the end of apartheid, the South African government has struggled to promote structural transformation, employment creation, and domestic value-addition in manufacturing. Several policy measures have attempted to address these issues in the country, with mixed results across sectors and firms (e.g., several rounds of the Industrial Policy Action Plan (IPAP)). The empirical evidence presented in this chapter has pointed to a relatively new but increasingly important policy challenge faced by South Africa (i.e., the impact of Chinese import penetration on the growth of manufacturing firms), which, however, should be analysed within the context of the overall deindustrialisation dynamics going on in the country.

The increase in direct Chinese import penetration between 2010 and 2017 has been estimated to account for around 4 per cent of the loss in manufacturing-wide firm employment growth and sales growth in South Africa, alongside a crowding-out process propagating upstream along the domestic value chain from the firms directly affected by Chinese imports to their suppliers. This double negative impact is critical as it results in the increasing disarticulation of the local production system and weakening of its nodes, while introducing further challenges in the implementation of localisation policies aiming at increasing domestic value-addition and linkages development. Understanding the competitiveness gap in terms of capabilities, price, and quality—in specific sectors and for specific product segments—between Chinese imported goods and South African firms becomes a key policy priority towards feasible interventions.

In this respect, the econometric results suggest how firms investing in capabilities development have managed to respond to Chinese import penetration in a relatively more effective way. While this latter result is encouraging and highlights the importance of supporting investment in production upgrading (including functional repositioning along the value chain), research, and skills, the fact that the negative impact of Chinese import penetration is still significant and only marginally smaller for firms investing in capabilities development points to further policy considerations. First, capabilities development and accumulation take time, and scale-appropriate and sustained investment efforts. The fact that only a very small percentage of firms are involved in significant investments, and that even within this group some firms show limited and discontinuous investment commitment, is alarming. Furthermore, the fact that in South Africa a limited number of firms are investing also means that other firms cannot benefit from the externalities typical of an industrial ecosystem with multiple firms specialising in complementary capabilities and involved in lateral migration. Chinese import penetration and competitive pressure are thus intertwined with a number of long-term structural problems of the South African production system as a whole, and specific weaknesses of its firms along several domestic value chains, including medium- and high-technology ones.

It is important to highlight at least two main limitations of this study. First, in this analysis, I have focused exclusively on the impact of Chinese import penetration on the growth dynamics of South Africa-based manufacturing firms. Although the total sales variable employed here also includes the turnover arising from firms' export activities, this chapter has not directly addressed the question of whether Chinese competition has also affected South African manufacturing exports. Chapter 4 deals precisely with this aspect, analysing the potential displacement or crowding-out effect on South African exports in selected manufacturing sub-sectors arising from growing Chinese imports in international markets in the same product categories. Second, the data limitations highlighted throughout the chapter – particularly the use of indirect measures of process, product innovation and skills development – make it difficult to further reveal the specific mechanisms and strategies that firms in South Africa developed in response to rising Chinese import competition. Assessing their effectiveness, and how firms' responses can reverberate and have mixed effects along domestic value chains, calls for more granular data and firm-level deep dives. Chapter 5 in Part II of this thesis, indeed, constitutes a decisive step in this direction.

Notwithstanding these limitations, against the fast-evolving global industrial landscape and rising trade tensions, more recently complicated by the global pandemic shock, the empirical evidence contained in the present chapter points to the importance of firms' investments in productive and technological capabilities development in middle-income countries like South Africa. It also underlines the fact that the competitive pressure from the new manufacturing superpower – China – can lead to disproportional upstream and downstream sectoral dynamics, including potential price dynamics and firm displacement effects. These are, indeed, critical in middle-income countries like South Africa where the industrialisation process has been characterised by a high degree of concentration in upstream industries, limited development of downstream sectors and poor firm-level investment performances.

The rise of China appears to have shifted the goal posts for firms in South Africa, intensifying the challenges they face. Responding to the rising competitive pressure exerted by China, while also capturing the opportunities it offers in terms of restructuring sectors and firms' specialisations, requires increased focus on the heterogeneous responses of firms and their effectiveness, but also industrial policies that can support both firm and system level linkages, development and competitiveness. Ultimately, while rising competitive pressure from Chinese imported products into the country matters, what South African firms and public institutions do about it is equally critical in determining the final impact of this complex 'dance with the dragons'.

Chapter 4

The displacement effect of China on South African exports of medium- and high-tech manufacturing products

4.1 Introduction

Over the past three decades, China has emerged as a major exporter of MHT manufacturing goods (Rodrik, 2006; Meri, 2009; US Census Bureau, 2011; see also Chapter 3 for evidence on Chinese MHT exports to South Africa). According to international trade statistics (UNCTAD, 2020), in 2018, these products amounted to over 60% of total Chinese manufacturing exports. This share has grown significantly since 1995, when it was slightly over 30%. During the same period, China's shares of MHT manufacturing imported by the rest of the world has grown dramatically as well (from less than 5% to over 15%).[70]

This significant increase has been primarily driven by China's participation in low value added stages of MHT GVCs: as reported by Xing (2014), in 2009, 82% of China's high-technology exports consisted of assembled and processed high-technology products, made of key components and parts imported from advanced economies. However, more recently, the literature has shown that China has gradually upgraded its position within GVCs by substituting intermediate goods with domestic produce (Kee and Tang, 2016) and by increasing the value added embodied in existing intermediate and final MHT goods produced domestically (Brandt and Thun, 2016).

According to available trade in value added statistics (OECD-TiVA, 2018), the domestic value added in Chinese exports of MHT industries rose from 65% in 2005 to 78% in 2015 (see also Figure 3.5, panel a, in Chapter 3 of this thesis for some additional evidence on this). The significant growth of China's global manufacturing exports during the past two decades and its transition from exporting mainly lower technology goods to more advanced products have

[70] In this chapter, MHT products refer to goods belonging to the following sectors: automotive, chemicals, plastics, iron and steel, engines and motors, non-electrical machinery, household appliances, pharmaceuticals, power generating equipment, computer and office machines, electronics and telecommunications, electrical machinery, scientific instruments. For further details on this classification and how it has been developed see Section 4.4.2 below.

strengthened concerns for other middle-income countries trying to build or retain a competitive edge in more technologically advanced sectors (Paus, 2019; Jenkins, 2014; Edwards and Jenkins, 2014; Jenkins and Edwards, 2015).

Over the years, South Africa has developed export capabilities in a number of MHT sectors, particularly in industrial machinery and automotive (Andreoni et al., 2021a). This has been achieved by building up and strengthening competitive domestic players, but also by attracting foreign direct investments from large multinational OEMs. Nonetheless, overall, the country has failed to take forward its industrialisation process, to diversify and upgrade the structure of its economy and, consequently, to enhance the competitiveness of its MHT global and regional exports (Andreoni and Tregenna, 2020, Andreoni et al., 2021a; Zalk, 2021).

Moreover, since the end of apartheid, while experiencing increasing integration into the global economy, South Africa, like many other developing countries, has also faced an intensification of competition from China, both domestically (Morris and Einhorn, 2008; Jenkins, 2008; Edwards and Jenkins, 2015; see also Chapter 3 of this thesis) and in third markets (Edwards and Jenkins, 2014; Jenkins and Edwards, 2015; Rustomjee et al., 2018). This evidence makes South Africa, a major G20 middle-income country, an excellent case study for identifying the competition (or substitution) and the complementary effects (Kaplinksy and Messner, 2008; Kaplinksy and Morris, 2008) of Chinese exports of MHT products on South African exports in the same product categories and directed to the same destinations.

To the best of my knowledge, up to now only the study by Edwards and Jenkins (2014) has provided econometric evidence on the Chinese export displacement effect in South Africa. They found that between 1997 and 2010 exports from China had a negative relative effect on exports from South Africa to other African markets, meaning that South African exports are either less positively affected or more negatively affected by Chinese exports relative to the exports of other countries. However, due to the specific empirical strategy and estimation method adopted, they were not able to estimate the level displacement effect, the sign of which remain ambiguous. Furthermore, although grouping the products in their sample according to the technology classification developed by Lall (2000), they did not explicitly focus on South Africa's MHT exports and they did not disaggregate technology categories further.

This chapter aims to expand and complement the study developed by Edwards and Jenkins (2014) by investigating whether, and to what extent, the rise of China's exports in MHT manufacturing products has displaced or complemented South African exports to third markets in the same product categories, over the 1995-2018 period. To this purpose, I develop an instrumental variable (IV) strategy to estimate the level displacement effect of Chinese exports on the exports of South Africa, focusing on the intensive-intensive margins of trade. This empirical approach is based on a number of previous works estimating the level displacement effect of Chinese exports (Eichengreen et al., 2004 and 2007; Greenaway et al., 2008; Giovannetti and Sanfilippo, 2009; Abu Hatab, 2017; Pham et al., 2017).

Specifically, in this chapter the presence of a Chinese crowding-out effect on South African exports of MHT products is analysed at different levels of disaggregation: (*i*) for the full sample of products at the 6-digit level exported by South Africa to all destination countries between 1995 and 2018; (*ii*) for each sub-sector within the MHT group of manufacturing products; (*iii*) for different groups of destination markets; (*iv*) for different sub-periods; and (*v*) by taking into account the role of Hong Kong as a major conduit for mainland China's world exports.

The empirical results show that, overall, Chinese exports of MHT manufacturing products have displaced competing South Africa exports in third countries during the years from 1995 to 2018. Thus, in general, when China and South Africa competed in the same MHT product category and same destination market, an increase in China's exports has been associated with a decrease in South African exports over the entire period under analysis. Nonetheless, the results display a certain degree of heterogeneity. China's crowding-out effect on South African exports to third countries has been more severe in specific sub-sectors (i.e., iron and steel, household appliances, metalworking machinery and machine tools, chemicals and electrical machinery) and destination markets (i.e., non-OECD countries, African and sub-Saharan economies in particular). Finally, my estimates reveal that this displacement effect is larger when taking into account only the sub-period following the GFC and when exports from Hong Kong are combined with those from mainland China.

The rest of the chapter is organised as follows. Section 4.2 reviews the relevant literature: it surveys previous empirical studies on the Chinese export displacement effect and contributions establishing the case for focusing specifically on the exports of MHT products. In Section 4.3 I present some preliminary descriptive evidence. Section 4.4 introduces the data and discusses the empirical strategy adopted in the chapter. The main findings are summarised and analysed in Section 4.5. Finally, Section 4.6 concludes, discussing some limitations and ways forward for future research.

4.2 Related literature

This section reviews two large bodies of literature which are particularly relevant for the present analysis. First, it looks at those contributions studying whether and to what extent the exponential growth of Chinese exports has displaced the exports originating from other countries in third markets. Second, it reviews key studies underlining the importance of examining in depth developing countries' production and export specialisation profiles. This second survey, in particular, aims at establishing the case for focusing on the effects of a surge in Chinese exports of MHT products on those originating from another middle-income country like South Africa.

4.2.1 Previous research on the Chinese export displacement effect

The exceptional rise and upgrading of China in world trade over the past three decades has caused concern among economists and policymakers in both developed and developing countries. This development has motivated many scholars to look into the effects that the exponential growth and the increasing upgrading of Chinese exports might have on world trade patterns. Specifically, it has prompted a large and growing body of empirical literature on whether, and to what extent, Chinese exports displace those originating from other countries in different destination markets.

In the review that follows, the most relevant academic contributions in this field are classified into three main groups (i.e., analyses of competitive threat through simulation models, through export similarity measures and through augmented gravity models). The main focus of this survey is on those empirical studies belonging to the third group which employ gravity modelling to investigate whether, and to what extent, Chinese exports crowd out those originating from other countries in third markets.[71]

4.2.1.1 Analyses of competitive threat through simulation models

The first group encompasses studies carried out mainly during the first half of the 2000s. These contributions explore the impact of China's accession to the WTO on 11 December 2001 on world trade, generally through simulation or computable general equilibrium (CGE) analyses based on the Global Trade Analysis Project (GTAP) model. These simulations are generally

[71] A comprehensive survey of the literature on how China's growth and upgrading in trade have reshaped world trade patterns is beyond the scope of the present chapter. In what follows, I will review only those studies most closely related to the present analysis.

oriented towards the year 2005 and beyond, when China's adhesion to the WTO would have been fully implemented.

In 2001, an initial study undertaken by World Bank staff predicted that the reduction in Chinese tariff rates following the country's WTO adhesion would have significantly boosted its production and exports of labour-intensive manufacturing products, especially within textiles and apparel sectors (Ianchovichina and Martin, 2001). The results of their simulation showed that China's share of world clothing exports would have reached over 47% in 2005 as a result of the WTO accession, while, within the context of a scenario without WTO accession, China's share would have been much lower (i.e., around 18.5%) in this sector (Ianchovichina and Martin, 2001, p. 435, Table 6). In a subsequent analysis, the same authors also reported that developing economies competing with China in third markets might face some losses in their export shares (Ianchovichina and Martin, 2004).

Focusing on East Asian countries, Ianchovichina and Walmsley (2005) found that China's WTO adhesion would have had a negative impact on the exports of developing and emerging economies in the region, such as Vietnam, the Philippines, Thailand, Indonesia and Malaysia. On the contrary, according to the authors, industrialised and newly industrialising economies (NIEs) in East Asia would have benefitted from China's WTO accession.[72] However, the results of the simulation performed by Ianchovichina and Walmsley (2005) also suggest that NIEs might have started to face higher competition in international markets as China's production and exports upgraded, and its comparative advantage shifted into MHT products.[73]

Nonetheless, as discussed extensively in Shafaeddin (2003), these CGE-based analyses suffer from a number of key shortcomings, including some methodological problems,[74] as well as unrealistic underlining assumptions.[75] As a result, these models generally tend to overestimate the impact of China's accession to the WTO on world trade patterns.

4.2.1.2 Analyses of competitive threat through export similarity measures

Given these limitations, a second group of studies has analysed the threat which Chinese exports pose to the exports of other countries using an alternative methodology. While employing different indicators and measures, all these empirical contributions focus on the

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72 This group of countries includes Japan, Hong Kong, South Korea, Singapore and Taiwan.

73 See also Shafaeddin (2004) on this.

74 As an example, these models only take into account the removal or changes of tariffs, neglecting the impact of the removal or reduction of subsides on exports for Chinese companies.

75 These include the assumption of immediate sectoral shifts in industrial output and employment, their growth at steady-state rates and the perfect mobility of labour among different sectors.

extent to which China's trade patterns resemble those of its competitors. They generally cover the period from the early 1990s to the mid-2000s, but the most recent ones extend the analysis up to the 2010s (Jenkins, 2014; Jenkins and Edwards, 2015).

Some scholars within this strand of the literature have estimated the correlation between the trade patterns of a certain country or group of countries and China.[76] Studies adopting this approach include Ianchovichina et al. (2003) and Lall and Alaladejo (2004) on East Asia, Meller and Contreras (2003), Lall et al. (2005) and Moreira (2007) on Latin America, and Jenkins and Edwards (2004) on 18 countries in Asia, Africa and Latin America.

Other contributions within this group have estimated the correlation between the revealed comparative advantage (RCA) of a certain country or group of countries and China by products.[77] Shafaeddin (2004) uses rank correlations between the RCA of China and other developing countries by product to identify those economies which suffer most competition from the rise of China's exports. Lederman et al. (2008) use an alternative RCA measure developed by Vollrath (1991) to estimate competition between China and Latin American countries, while Goldstein et al. (2006) employ RCA indices to look at the implication of the rise of China's and India's exports in the global markets on the exports of African countries.

Finally, this group also encompasses studies employing the export similarity index (ESI),[78] originally developed by Finger and Kreinin (1979), and related indicators such as the coefficient of specialisation and the coefficient of conformity (Jenkins, 2008b). The ESI and related approaches have been used to analyse the extent to which Chinese exports compete with exports of other Asian economies (Wu and Chen, 2004), Latin America countries (IDB, 2004), sub-Saharan Africa (Jenkins and Edwards, 2006; Goldstein et al., 2006) and on a very large number of countries from all geographic regions (Schott et al., 2008).

Most of these contributions find that the competitive threat which Chinese exports pose to other developing countries' exports in third markets has been confined to few, mainly Asian, economies (Meller and Contreras, 2003; Shafaeddin, 2004). These studies show that the impact of Chinese exports on other developing countries' exports to third markets has been relatively

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[76] Some of these studies have used correlation coefficients while others have employed rank correlations. In both cases the index's value ranges between +1 for countries with an identical export structure and -1 for countries with totally dissimilar export profiles (Jenkins, 2008b).
[77] The most common RCA index used in these studies is the Balassa indicator (Jenkins, 2008b).
[78] This index is intended to measure the similarity between exports of any two countries (or country groups) to the world market or to specific third destination markets. It is built from the share of each product in each country's total exports and it is defined as the sum of the minimum value for each product (Jenkins, 2008b).

limited,[79] with the partial exceptions of Mexico in Latin America and South Africa in sub-Saharan Africa (Blazquez-Lidoy et al., 2007; Lederman et al., 2008; Lall et al., 2005; Goldstein et al., 2006). However, using a newly developed dynamic index of competitive threat in addition to the more standard static measure, Jenkins (2008b) shows rising shares of exports under threat for many developing countries, including South Africa, Mozambique, Uganda, Mexico and Brazil, over the 1990-2002 period. These findings were also confirmed and expanded upon more recently in Jenkins (2010 and 2014) for Latin American countries, and Brazil in particular, and in Jenkins and Edwards (2015) for South Africa, using a variety of different indicators. These more recent works have also applied constant market share (CMS) analyses with the aim of shedding some light on the quantitative significance of Chinese competition for other countries' exports in third markets. Contrary to many previous studies, they found that China has had a significant impact on the exports of many Latin American countries over the 1996-2006 period (Jenkins 2010), particularly Brazil since 2004 (Jenkins, 2014),[80] and South Africa, after China's WTO accession, from 2001 to 2010 (Jenkins and Edwards, 2015).[81]

4.2.1.3 Analyses of competitive threat through augmented gravity models of international trade

The third group of studies reviewed in this section used gravity modelling[82] to investigate whether, and to what extent, the rise of China's exports has displaced or complemented other countries' exports to third destination markets. To this purpose, the standard gravity equation has been augmented, including as a key regressor Chinese exports to the same markets and in the same sector of the exporting countries under analysis (see Section 4.4 for further methodological details on this). The time span covered by these contributions varies, with the older ones focusing on the years between the early 1990s and the mid-2000s, and the most recent ones extending the period under analysis up until 2013 (Pham et al., 2017). Table 4.1 summarises the most important studies using this approach, briefly describing their sample,

[79] These studies generally find that the trade profile of Latin America and the Caribbean is largely complementary to that of China (Lall et al., 2005), and that only in a very few cases do African countries export in the same industries as China (Giovannetti and Sanfilippo, 2009).
[80] The analysis developed by Jenkins (2014) suggests that Brazil has lost markets to China in the USA, in the EU and in its major Latin American markets not only in low-technology products, but also increasingly in MHT ones. This effect has become stronger in the aftermath of the GFC, especially in the Latin American market.
[81] With respect to South Africa, Jenkins and Edwards (2015) show that all types of manufactured exports directed to all destinations (i.e., USA, EU, other sub-Saharan African countries) lost ground to China. However, the impact is significantly stronger for low-technology goods and for goods shipped to other sub-Saharan African markets.
[82] In their simplest form, gravity models of international trade predict bilateral trade flows based on the economic size and the physical distance between two geographical units. See Section 4.1 for further details on this.

time span, empirical specification and estimation strategy. The main results of these contributions are reviewed below.

Starting with the seminal works of Eichengreen et al. (2004 and 2007), a number of studies have focused on the crowding-out effect of Chinese exports on exports originating from other Asian countries in various destination markets (Eichengreen et al., 2007; Greenaway et al., 2008; Amann et al., 2009; Athukorala, 2009; Kong and Kneller, 2016). The main findings from these studies are inconclusive. The results of the preferred specification of Eichengreen et al. (2007) lead to a statistically insignificant overall crowding-out level effect. However, they also find that the effect of Chinese exports on the exports of other Asian economies in third markets was negative for consumer products, but positive for capital and intermediate goods. An implication of this result is that the Asian exporters of capital and intermediate products (i.e., mainly middle- and high-income economies) were positively affected while other countries, generally low-income ones, were not.

Estimating a model similar to that of Eichengreen et al. (2007), but with aggregate trade data, Greenaway et al. (2008) find very different results. Their work reports an overall displacement effect of Chinese exports on the other Asian exporters. However, they also find that China had no discernible crowding-out impact on low- and middle-income Asian exporters, while negatively affecting high-income exporters. Amann et al. (2009) focus on the impact of the rise of China's textile and clothing sector on the exports of its Asian competitors. They find that lower income economies in the region were more negatively affected, since they tended to specialise in segments of the textile and clothing value chain which were more exposed to Chinese competition. Athukorala (2009) looks in particular at the impact of Chinese exports of machinery and transport equipment on the exports of all other countries in the same product category, finding a highly significant displacement effect across all model specifications. However, the author does not find much evidence that East Asian countries are more adversely affected by Chinese competition than other countries in other regions.

All these studies employ an IV estimation strategy, focus on the intensive margins of trade (i.e., the volume of exports in value) and estimate the level displacement effect (see Table 4.1). As underlined by Kong and Kneller (2016), they do not include country-year fixed effects in their models, thus they do not control for time varying multilateral resistance terms (Baldwin and Taglioni, 2006). Kong and Kneller (2016) solve this estimation issue by including three sets of exporter-year, importer-year and country-pair fixed effects. However, this means that they are not able to estimate the level displacement effect, but only the relative displacement effect.[83] They find that countries with higher capital-labour ratios and human capital levels relative to China experience more export growth or a lower crowding-out effect in light of increasing Chinese exports.

A group of related studies have also estimated the effect of Chinese exports using gravity modelling, but without a specific focus on other Asian countries. Giovannetti et al. (2013) estimate the level effect of rising Chinese exports on EU exports to OECD markets. They do not find evidence of an overall level displacement effect of Chinese exports: it varies according to the specific sectors and exporting countries considered. Pham et al. (2017) analyse the effect of China's high-technology exports on other exporters of high-technology products, both developing and developed countries. They find that high-technology products exported from China are substitutes to other developing countries' exports of high-technology goods, but complementary to those of advanced economies.

Other contributions have focused on the effect of Chinese exports on African countries' trade. Geda and Meskel (2008) and Giovannetti and Sanfilippo (2009) each consider the manufacturing sector and analyse whether Chinese exports have displaced exports from African countries. Both studies find evidence that Chinese exports are crowding out African exports in third markets. In particular, Giovannetti and Sanfilippo (2009), using highly disaggregated data at the 6-digit product level, find that this displacement effect has been especially severe in the textile and clothing sectors, and in the machinery and equipment industries. Montinari and Prodi (2011) study China's impact on intra-African trade and conclude that exports from the sub-Saharan African countries to China increase intra-African trade for small exporters and reduce it for large ones. Chinese imports in sub-Saharan African countries, on the other hand, do not have a statistically significant effect on intra-African trade.

Few studies have focused on single country case studies. To the best of my knowledge, the work by Edwards and Jenkins (2014) is the only one so far that has focused on South Africa, using gravity modelling. Specifically, the authors estimate the relative displacement effects of China's export growth along both the extensive and intensive margins on South Africa's export performance in other African markets, between 1997 and 2010. They find that the major impact was on the intensive-intensive margin, that is to say the effect of growing Chinese exports in terms of value on the value of South African exports. According to their results,

[83] Since the measure of Chinese exports only varies with destination and time it cannot be separated from the multilateral resistance terms. Thus, in their preferred specifications, the Chinese exports' variable does not appear without the interaction with a factor endowment variable. This, in turn, allows the authors to estimate only the relative Chinese exports displacement effect (Kong and Kneller, 2016).

exports from China had a negative relative effect on exports from South Africa to other African countries for all the product groups considered, and especially for low- and medium-technology goods. This means that South African exports are either less positively affected or more negatively affected by Chinese exports relative to the exports of other countries. However, similarly to Kong and Kneller (2016), due to the empirical specification and estimation strategy chosen, they were not able to estimate the level displacement effect, the sign of which remain ambiguous. In another country study, Abu Hatab (2017) analyses the extent to which the export growth of Chinese textiles has come at the expense of Egyptian textile exports in third importing markets, over the 1994-2012 period. His results suggest that Egyptian textiles have lost ground due to the competitive pressure stemming from China in third markets, especially in the EU and in the United States, which collectively absorb more than two-thirds of Egyptian textile exports. Furthermore, this study shows how the expiration of the MFA in 2005 has exacerbated the negative effects of China on Egyptian textile exports to all importing markets.

All these studies focusing on countries other than Asian ones, with the exceptions of Geda and Meskel (2008), Montinari and Prodi (2011) and Edwards and Jenkins (2014), employ an IV estimation strategy inspired by the one developed in Eichengreen et al. (2007) and Greenaway et al. (2008). All, except Edwards and Jenkins (2014), focus only on the intensive margins of trade and estimate the level displacement effect, without, however, being able to control for time varying multilateral resistance in their estimations (see Table 4.1).[84]

[84] From this review of the studies employing gravity modelling to analyse the Chinese export crowding-out effect, it is clear that the works estimating the level displacement effect do not take into account time varying multilateral resistance (Eichengreen et al., 2007; Greenaway et al., 2008; Giovannetti and Sanfilippo, 2009), while the contributions that account for it are only able to estimate the relative displacement effect (Edwards and Jenkins, 2014; Kong and Kneller, 2016). See also Table 4.1 on this.

Table 4.1. Review of the literature on the Chinese export displacement effect using gravity modelling.

Study	Sample	Time frame	Trade data	Displacement effect and margins	Empirical strategy and estimation method
Eichengreen et al. (2007)	13 Asian exporters; 180/149 importers.	1990-2003	Aggregated; capital, intermediate, consumer goods.	Level effect. Intensive-intensive.	IV estimation: China's distance (with time fixed effects) or China's economic distance (with country-pair and country fixed effects); no control for time varying multilateral resistance.
Greenaway et al. (2008)	13 Asian exporters; 170 importers.	1990-2003	Aggregated.	Level effect. Intensive-intensive.	IV estimation (TSLS/GMM): China's distance and China's GDP (without time and country-pair fixed effects); no control for time varying multilateral resistance.
Amann et al. (2009)	13 Asian exporters; 154 importers.	1990-2005	Textile and clothing exports.	Level effect. Intensive-intensive.	IV estimation (TSLS/GMM): China's distance, China's GDP, China's real exchange rate and China's domestic output of textiles and clothing (without time and country-pair fixed effects); no control for time varying multilateral resistance.
Athukorala (2009)	39 exporters; 39 importers.	1992-2005	Total manufacturing; machinery and transport equipment; parts and components, final goods.	Level effect. Intensive-intensive.	IV estimation (TSLS/GMM): China's distance, common language, share of foreign invested firms in total manufacturing exports from China (with time fixed effects and without country-pair fixed effects); no control for time varying multilateral resistance.
Geda and Meskel (2008)	13 African exporters; 6 importers.	1995-2005	Clothing and accessories.	Level effect. Intensive-intensive.	OLS estimation, with time fixed effects and without country-pair fixed effects; no control for time varying multilateral resistance.
Giovannetti and Sanfilippo (2009)	48 African exporters; 64 importers.	1995-2005	6-digit product data; full sample, total mfg, 9 mfg sectors, textile and machinery sub-sectors.	Level effect. Intensive-intensive.	IV estimation (TSLS/GMM): China's distance (with time fixed effects and without country-pair fixed effects); no control for time varying multilateral resistance.

Source: Own elaboration, based on review of the literature.

Table 4.1. Review of the literature on the Chinese rt displacement effect using gravity modelling (*continued*).

Study	Sample	Time frame	Trade data	Displacement effect and margins	Empirical strategy and estimation method
Montinari and Prodi (2011)	43 African exporters; 46 African importers.	1999-2007	Aggregated.	Level effect. Intensive-intensive.	OLS estimation, with time fixed effects and with time and countries fixed effects; no control for time varying multilateral resistance.
Giovannetti et al. (2013)	4 EU exporters; 31 OECD importers.	1995-2009	SITC rev. 3 at the 2-digit level.	Level effect. Intensive-intensive.	IV estimation (TSLS/GMM): China's distance (without time fixed effects and without country-pair fixed effects); no control for time varying multilateral resistance.
Edwards and Jenkins (2014)	18 exporters (including South Africa); 10 African importers.	1997-2010	4-digit product data, full sample and by technology class (Lall, 2000).	Relative effect. Intensive-intensive, intensive-extensive, extensive-intensive, extensive-extensive.	OLS estimation, with country-year-product fixed effects; control for time varying multilateral resistance.
Kong and Kneller (2016)	7 Asian exporters; 186 importers	1994-2008	Mfg goods, part components, final goods.	Relative effect. Intensive-intensive.	OLS estimation, with full set of country-year fixed effects; control for time varying multilateral resistance.
Abu Hatab (2017)	Egypt as exporter; 89 importers.	1994-2012	Textile products.	Level effect. Intensive-intensive.	IV estimation (TSLS/GMM): China's distance, and China's GDP (without time fixed effects and without country-pair fixed effects); no control for time varying multilateral resistance.
Pham et al. (2017)	16 exporters; 56 importers.	1992-2013	6-digit product data, 6 high-tech mfg sectors (Hatzichronoglou, 1997).	Level effect. Intensive-intensive.	IV estimation: China's distance, and China's GDP (with exporter fixed effect, without time fixed effects and without country-pair and country-time fixed effects); no control for time varying multilateral resistance.

Source: Own elaboration, based on review of the literature.

To conclude, the empirical literature employing gravity modelling to estimate the Chinese export displacement effect is rather inconclusive. Results vary with the use of different empirical strategies, estimation methods, sample compositions, time dimensions and levels of aggregation of trade data. Building on the contributions listed within this last group of empirical studies, I investigate whether and to what extent the rise of China's exports in MHT manufacturing products has displaced (or complemented) South African exports to third markets in the same product categories, over the 1995-2018 period. To this purpose, the empirical strategy employed in the present study and described in detail in Section 4.4 below is based on the works estimating the level displacement effect of Chinese exports (Eichengreen et al., 2007; Greenaway et al., 2008; Giovannetti and Sanfilippo, 2009; Abu Hatab, 2017; Pham et al., 2017).

This work aims to complement the only available study focusing on South Africa (Edward and Jenkins, 2014) in five ways: first, by estimating the level displacement effect on the intensive-intensive margins of trade, that is the effect of growing Chinese exports on the value of South African exports; second, by extending the time period under analysis up until 2018; third, by taking into account the role of Hong Kong as a major conduit for mainland China's world exports, as in Greenaway et al. (2008) and Pham et al. (2017); fourth, by looking at how this level displacement effect varies according to the specific sub-sector and destination market under consideration; and fifth, by focusing specifically on the exports of MHT products at a very detailed level of disaggregation.

With respect to this last point in particular, apart from Pham et al. (2017), who restrict their analysis to certain high-technology exports, none of the studies reviewed above explicitly focused only on the exports of MHT products. Some authors explored the impact of China's exports growth at the aggregate level (Greenaway et al., 2008); others distinguished between capital, intermediate and final goods (Eichengreen et al., 2007); and still others focused on specific industries like the textile and clothing sectors (Geda and Meskel, 2008; Amann et al., 2009; Abu Hatab, 2017; Giovannetti and Sanfilippo, 2009) or the machinery and equipment sectors (Athukorala; 2009; Giovannetti and Sanfilippo, 2009). Finally, while Edwards and Jenkins (2014) grouped the products in their sample according to the technology classification developed by Lall (2000), they did not explicitly focus on South Africa's MHT exports and they did not disaggregate technology categories further.

This chapter's focus on export competition in MHT products has its roots in those strands of the literature on economic development which establish the case for examining in depth countries' production and export specialisation profiles. Key contributions within this literature, closely related to the present work, are briefly reviewed above.

4.2.2 On countries' export specialisation profile and their development prospects

A key question is therefore: why should one focus explicitly on MHT exports? In this respect, a number of seminal studies within the structuralist and evolutionary literature have underlined that specialisation in technology-intensive activities matters for the future growth prospects of both developed and developing countries (Nelson and Winter, 1982; Fagerberg, 1988; Fagerberg et al., 2007; Dalum et al., 1999; Lall, 2000). In his influential work, Lall (2000) listed a number of reasons why this is the case. First, MHT sectors represent the fastest developing industries in international trade. Second, relative to simple technologies (i.e., primary goods, resource-based and low-technology manufacturing), MHT products have a stronger learning potential, because they provide greater scope for developing and applying new scientific knowledge. Finally, they are also characterised by greater dynamism and larger spillover effects in terms of creating new capabilities and generic knowledge that can be used in other activities across the economy. More recently, Lin and Wang (2020) have also shown that MHT manufacturing sectors make more intense use of production services than low and medium-low technology manufacturing industries. This stylized fact suggests that the development of MHT sectors, rather than the expansion of lower technology industries, might stimulate the growth of related service sectors.[85]

A number of empirical studies rooted in the neoclassical approach to economics have also shown that countries' economic performances are not entirely driven by country-specific fundamentals like factor endowment (i.e., labour, capital, natural resources), human capital and institutional quality, but also by the type of products these economies export (Hausmann et al., 2007; Hidalgo and Hausmann, 2009; Hausmann and Hidalgo, 2011). Accordingly, in these contributions, the "income level of countries' exports" (Hausmann et al., 2007) or their "economic complexity" (Hidalgo and Hausmann, 2009; Hausmann and Hidalgo, 2011) have been identified as good predictors for the subsequent economic growth of countries.

With special reference to middle-income economies, Eichengreen et al. (2014) underline how countries with a relatively large share of high-technology products in their export baskets are more likely to avoid falling or being stuck in the middle-income trap. However, many of these

[85] The model developed by the authors also shows that if a middle-income country fails to upgrade its manufacturing sector towards MHT activities or fails to develop its production service sector, it is more likely to fall into the middle-income trap (Lin and Wang, 2020).

countries, especially South American ones, have not made significant progresses in terms of their exports' sophistication and complexity during the past three decades, and in some cases they have even reverted to their comparative advantage in natural resources (Paus, 2017). Similar conclusions have been drawn on South Africa in a recent report published by CCRED (Bell et al., 2018), in which the country's export baskets of 1995 and 2016 are compared with each other. Within this context, the growing and evolving role of China in world trade during the past three decades has been seen as a key factor exacerbating the major challenges faced by many middle-income countries in keeping pace with technological change and innovation and, thus, in moving from a factor-driven to an innovation-driven model of growth (Paus, 2019; Andreoni and Tregenna, 2020).

During this period, China has become internationally competitive in low-technology as well as in MHT products. As shown by Rodrik (2006) and Schott et al. (2008), in the mid-2000s, Chinese exports were already more sophisticated and showed more overlap with OECD countries' exports compared to those originating from other developing economies. The dramatic expansion of China's commercial weight, and its structural transition from being an exporter of low-technology goods (e.g., textiles) to more advanced products (e.g., machine tools), has also been accompanied by a gradual upgrading of the country's firms from assemblers to producers and integrators of components along GVCs, even in some advanced manufacturing technology segments (Fu 2016; Tassey 2014; Zhou et al. 2016). The literature, indeed, has shown that, starting from a modest level of value added embodied in its exports (Branstetter and Lardy, 2006; Xing, 2014), China has gradually upgraded its position within GVCs by substituting intermediate goods with domestic produce (Kee and Tang, 2016) and by increasing the value added embodied in existing intermediate and final goods produced domestically (Brandt and Thun, 2010 and 2016; see also Figure 3.5, panel a, in Chapter 3 of this thesis for some additional evidence on this).

The dramatic technological upgrading of Chinese exports and their growing domestic value-addition has changed the nature of Chinese competitive pressure on other developing countries (Paus, 2019). In particular, the increasing sophistication of Chinese exports poses particular challenges to South Africa, another middle-income country and a regional economic power, which, since the end of the apartheid, has faced persistent structural transformation challenges (Andreoni and Tregenna, 2020). The lack of structural change in the country is also captured, among other things, by its undiversified export basket, which is still disproportionally skewed toward mineral and resource-based products (i.e., accounting for 57% of its total merchandise exports in 2019) with some limited niches of excellence in terms of export capabilities in certain MHT manufacturing sectors (Andreoni et al., 2021a; Zalk, 2021). Yet, South Africa's gains from trade for this type of products threaten to be eroded by China's increased involvement in exports of more advanced manufacturing goods, both at the global level and in the region. Such competitive pressure may prevent South Africa from capturing the gains of "learning by exporting" diversified and more advanced manufacturing products (Bell et al., 2018). And, as underlined by Edwards and Jenkins (2014), it might undermine the country's global export prospects as well as its central position in regional value chains (i.e., as a gateway for foreign and local investors and traders to access the rest of the African continent).

It is important to point out that, in the present study, export volumes are those recorded when products are shipped out of the border of the exporting country (i.e., China and South Africa in this case). Thus, within the context of this analysis, I focus exclusively on competition between China and South Africa in terms of gross exports of MHT products directed to third destination markets, and not in terms of trade in value added. This means that I take into account these two countries' roles as assembly and export platforms in global production networks, but without being able to isolate and study the production and assembly processes going on within their borders and linked to their export activities. This approach is very similar to the one adopted in Chapter 3 of this thesis to build direct and indirect import penetration variables, and it is motivated by the same considerations about data limitations. In fact, as already underlined in Section 2.4 of Chapter 2 of this thesis, bilateral data on trade in value added are not currently available for products at a very disaggregated level for the same number of destination countries or for the same time period under consideration here.

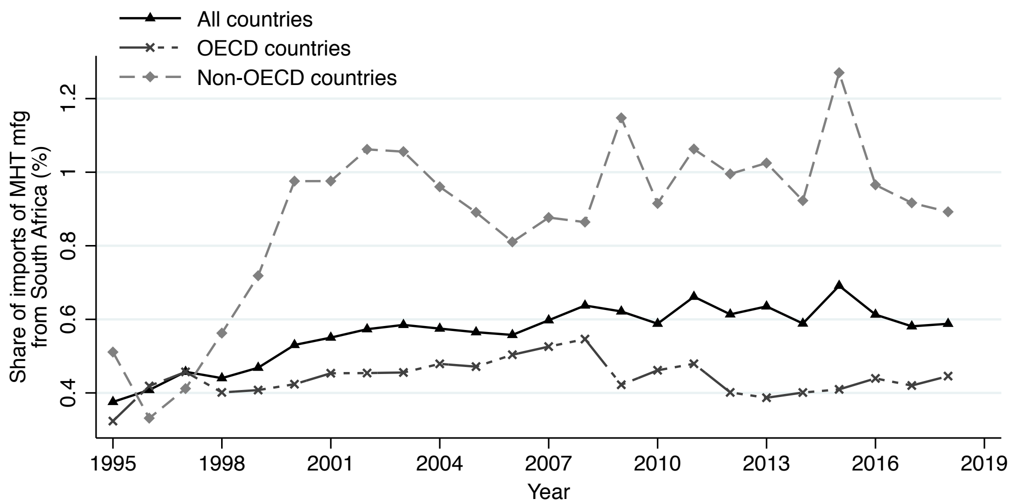
However, in this chapter – in a similar way to in Chapter 3 – I do not require exporters (i.e., China and South Africa in this case) to be the sole producer of the products they ship abroad, although I am aware that some of these exports are produced by export processing plants, which import key parts from abroad, assemble these inputs and export the final goods (Srholec, 2007). The availability of detailed information on the domestic and foreign content of countries' exports at a very disaggregated product level would improve our understanding of the actual competition dynamics between emerging economies along GVCs significantly.

4.3 An explorative descriptive analysis

Figures 4.1 to 4.3 show the evolution over time, between 1995 and 2018, of South Africa's and China's shares of MHT manufacturing imported by different groups of countries.[86]

As reported in Figure 4.1, South Africa accounts for a very modest share of MHT world imports. During the period under analysis, this went from slightly less than 0.4% in 1995 to around 0.6% in 2018, with peaks up to 0.7% since 2008. When the sample is slitted among OECD and non-OECD countries, some heterogeneity is detected, although South Africa's share of MHT manufacturing imported by these two large groups of countries are still quite negligible. In 2018, South Africa accounted for slightly more than 0.4% MHT manufacturing imported by OECD countries[87] and for around 0.9% of those imported by non-OECD economies. Following the ending of apartheid, South African export market shares of MHT manufacturing shipped to other developing countries grew rapidly, from less than 0.4% in 1996 to around 1% in 2000. Since then, this share has moved around an average value of 0.9%.

Figure 4.1. South Africa's share of MHT imports to different markets.



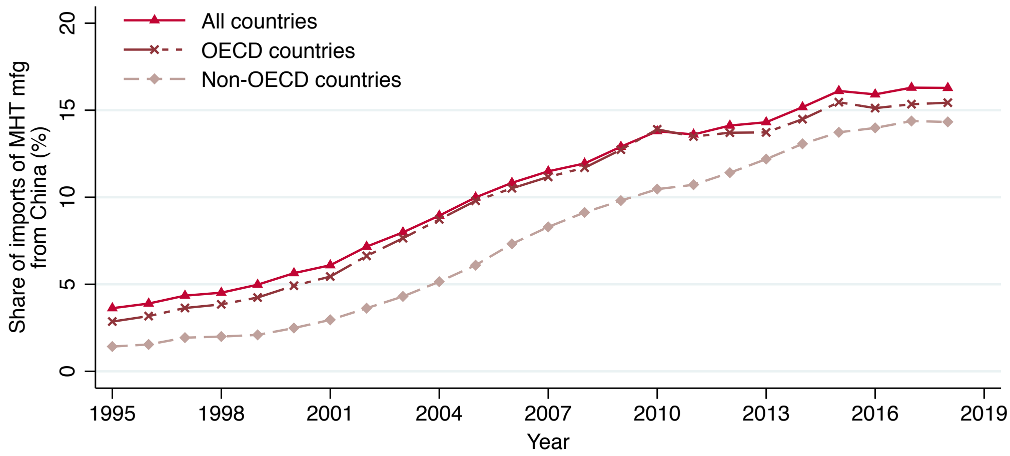
Source: Own elaboration, based on data UN Comtrade (2020).

[86] As in the previous empirical chapter, I decided to use the technological classification proposed by Lall (2000), because I believe it is more appropriate for a middle-income country like South Africa than the one developed by Hatzichronoglou (1997) and used by the OECD, which is based on direct R&D intensity and R&D embodied in intermediate and investment goods in a subset of advanced countries. For further details on this see Section 4.4.2.

[87] Although certain OECD countries such as Germany, United Kingdom, United States and Japan account for a significant share of South Africa's exports of medium and high-technology manufacturing, the results shown in Figure 4.1 for OECD economies reflect the large size of many of these markets.

In contrast, the import share accounted for by China is significant across all groups of countries (i.e., world, OECD, non-OECD) and it has been rising dramatically since the mid-1990s. As shown in Figure 4.2, by 2018 China accounted for around 15% of MHT manufactured imports in the world, in OECD and in non-OECD countries. With an initial value of 5% in 1995, China's share of imports of MHT manufacturing imported by all these markets started to accelerate, particularly since 2001, when the country became a member of the WTO.

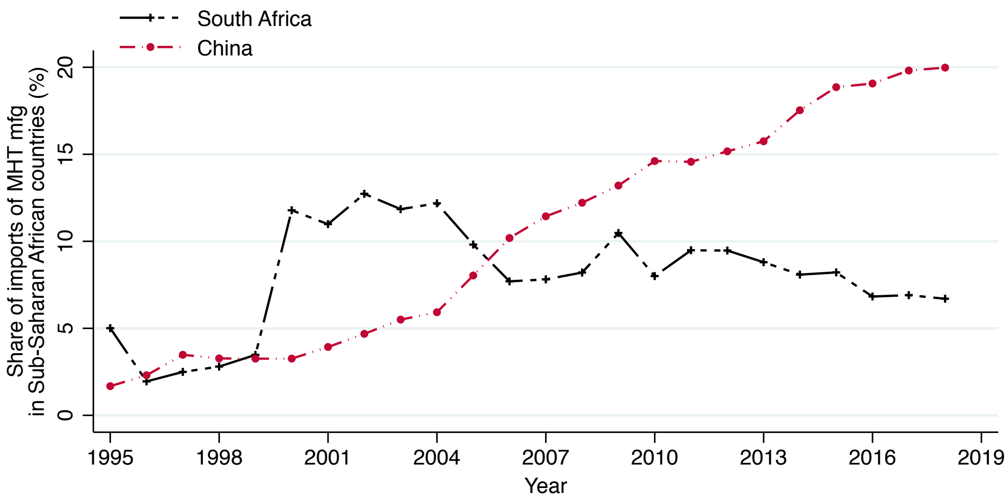
Figure 4.2. China's share of MHT imports to different markets.



Source: Own elaboration, based on data UN Comtrade (2020).

Figure 4.3 focuses exclusively on the sub-Saharan African markets, comparing South Africa's and China's shares of MHT imports in these importing countries and the evolving trend from 1995 to 2018. South Africa is an important source of MHT imports for sub-Saharan economies: starting from a share of 5%, by 2000 South Africa accounted for more than 12% of MHT manufactured imports in the region. This share has declined considerably since 2004, reaching a level of 6.7% in 2018. At the same time, China has experienced an impressive growth in its share of MHT manufacturing imported by sub-Saharan African countries, overtaking South Africa's share in the same product categories from 2006. Over the period under analysis, this share went from slightly less than 2% in 1995 to around 20% in 2018 (i.e., 5 percentage points above China's share of MHT world imports reported in Figure 4.2).

Figure 4.3. South Africa's and China's share of MHT imports to sub-Saharan Africa.

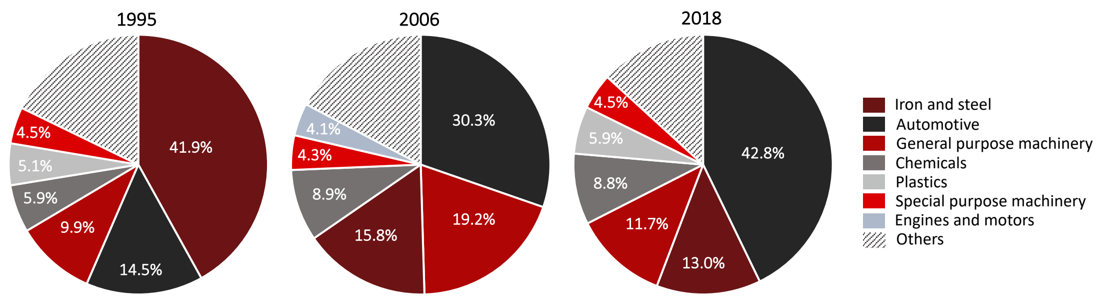


Source: Own elaboration, based on data UN Comtrade (2020).

Figures 4.1 to 4.3 show that over the past decade South Africa's share of imports of MHT manufacturing into different groups of export markets has been stagnating or even declining, while that of China has increased significantly. However, these trends at the aggregate level give no indication of the specific MHT products and regional markets in which China and South Africa compete with each other.

To shed some light on this aspect, Figures 4.4 and 4.5 report the sectoral and regional composition of South African MHT exports (in value terms) that face Chinese competition in third markets, for the years 1995, 2006 and 2018. These figures show the extent of overlap between South African and Chinese products exported.

Figure 4.4. Sectoral composition of South African exports facing competition from China in third markets.

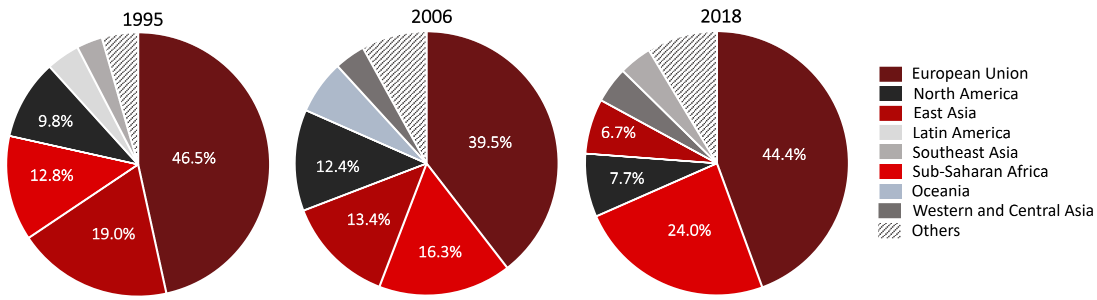


Source: Own elaboration, based on data UN Comtrade (2020).

Figure 4.4 shows that a share between 82% and 87% of the total export value of MHT products for which South Africa faced competition from China in international markets is accounted for by only six medium-technology sectors per year. These include the automotive industry, a number of sectors within the metal-machinery value chain (i.e., iron and steel, general and special purpose machinery), chemicals, plastics and, only in 2006, engines and motors.

In 2018, almost 43% of the total South African MHT exports for which the country competes with China in third markets was represented by automotive products (up from a modest 14% in 1995). The cluster of products, including manufactured iron and steel goods, general and special purpose machinery, amounted to around 30% of the total export value of MHT products for which South Africa faced competition from China in international markets in 2018. This share has decreased from about 54% in 1995, and at the same time there has been a gradual shift towards downstream machinery and equipment sectors, away from iron and steel products.[88]

Figure 4.5. Regional composition of South African exports facing competition from China in third markets.



Notes: European Union refers to EU28 (i.e., the current EU27 plus United Kingdom).
Source: Own elaboration, based on data UN Comtrade (2020).

In terms of regional composition, in 2018, over 44% of the total South African MHT exports for which the country competes with China in third markets were directed to European Union countries. This share has not changed much since 1995. In 2018, a share of around 24%, 8% and 7% was represented by South African MHT exports to other sub-Saharan African countries, to the United States and Canada, and to East Asian economies, respectively. While the shares of exports directed to North American and East Asian countries have declined since 1995, that of exports directed to other sub-Saharan African economies has increased from slightly less than 13% in the same year.

Figures 4.4 and 4.5 show that the MHT products for which South Africa and China compete in international markets are mostly concentrated into a handful of medium-technology sectors

[88] Figure 4.4 is mainly used here to highlight the sectors in which the competition in international markets between South Africa and China is concentrated. It is important to point out that the time evolution of these sectoral shares might also be driven by domestic dynamics in one country or both.

and directed to four macro-regions. This evidence obviously reflects both the sectoral and the geographical export specialisation patterns of South Africa with respect to the subset of MHT products (Andreoni et al., 2021a; Bell et al., 2018).[89]

While informative, the evidence shown in this section does not shed any light on the impact of the competition stemming from the rise of Chinese exports in MHT products on South African ones in the same product categories and destination markets. In order to explore whether, and to what extent, the rise of China's exports in MHT manufacturing products has displaced South African exports to third markets in the same product categories, over the 1995-2018 period, the following sections introduce, explain and estimate an econometric model employing far more disaggregated data.

4.4 Data and methods

4.4.1 The augmented gravity model for analysing the export displacement effect

The gravity model of international trade, in its basic set-up, posits that the volume of transactions between two trading partners is positively associated with their economic size and negatively influenced by the geographic distance between them. In this model, countries' GDP is usually employed as the preferred indicator of their economic size. In some formulations GDP per capita is also included to reflect a country's level of development, in addition to its economic size. The basic gravity equation is often then augmented to include a number of additional country-specific variables affecting bilateral trade, such as indicators of cultural affinity, participation in trade agreements, colonial relationship and various geographic characteristics.

Thus, the standard gravity model focuses on the three key drivers of bilateral trade volumes. First, it considers the role of export supply, which is generally captured by the exporter's GDP and/or GDP per capita. Second, it looks at the relevance of import demand, which is proxied by means of the importer's GDP and/or GDP per capita. Third, it takes into account trade resistance, which is mainly expressed in terms of the geographic distance between trading partners, but is also captured by a number of indicators representing cultural, policy, and other logistical and transport barriers to trade.

[89] A key shortcoming of the measure used to identify the products and regional markets in which China and South Africa compete the most with each other is that it does not differentiate between products for which China is a major exporter and those for which it only exports very modest amounts (in value terms).

Since its original formulations (Tinbergen, 1962; Pöyhönen, 1963) the gravity model has been widely used in applied econometric works, thanks to its undeniable intuitive appeal and its high empirical relevance (De Benedictis and Taglioni, 2011; Anderson, 2011; Dueñas and Fagiolo, 2013; Mayer, 2014).[90] Gravity models, for instance, have been adopted to explore the effect on bilateral transactions of trade-related policies, including WTO membership (Rose, 2004; Subramanian and Wei, 2007; Grant and Boys, 2011; Dutt et al., 2013), participation in currency unions (Rose and Van Wincoop, 2001; Nitsch, 2002; Rose, 2002; Serlenga and Shin, 2004; Barro and Tenreyro, 2007) and free trade agreements (Baier and Bergstrand, 2007; Baier and Bergstrand, 2009; Egger et al., 2011; Baier et al., 2014; Dai et al., 2014). Some empirical studies employing gravity models have focused on the impact on bilateral trade of colonial relations (Head et al., 2010; Berthou and Ehrhart, 2017) and non-tariff barriers (Disdier et al., 2008, Disdier et al., 2015). Applied studies in evolutionary economics have employed gravity model specifications to investigate the technology-gap impacts on trade (Soete, 1981). Finally, in other empirical analyses, gravity models have been used to explore the relationship between trade and cross-border investments (Egger and Pfaffermayr, 2004; Bezuidenhout and Naudé, 2010).

Over the past decade and a half, starting with the seminal work of Eichengreen et al. (2004 and 2007), modified versions of standard gravity models have also been adopted to investigate the impact of the growth of exports originating from China on other countries' trade performances (Greenaway et al., 2008; Geda and Meskel, 2008; Giovannetti and Sanfilippo, 2009; Giovannetti et al., 2013; Edwards and Jenkins, 2014; Kong and Kneller, 2016; Pham et al., 2017). These and other works analysing the crowding out effect of Chinese exports on different sub-samples of destination countries, through the lenses of the gravity model, have already been reviewed as part of the literature survey carried out in Section 4.2. To this purpose, in such studies, the traditional gravity equation has been augmented, including as a key regressor Chinese exports to the same markets and in the same sector or product.

Building on these empirical contributions, in the present study I adopt the following baseline gravity specification:

$$\log(EXP)_{ZAF,j,h,t} = \alpha + \beta_1 \log(EXP)_{CHN,j,h,t} + \beta_2 \log(GDP)_{ZAF,t} + \beta_3 \log(GDP)_{j,t}$$

[90] The theoretical foundations of the gravity model remained underdeveloped up to the early 1980s. Until that time all contributions and applications dealt with the empirics of the relationship (De Benedictis and Taglioni, 2011). Then, starting with the seminal work by Anderson (1979), subsequent studies have contributed to provide the theoretical basis for the gravity model, showing that it can in fact be derived from a number of different theories of trade with possibly conflicting micro-foundations (Bergstrand, 1985; Deardorff, 1995; Eaton and Kortum, 2002; Evenett and Keller; 2002).

$$+\beta_4 \log(dist)_{ZAF,j} + \beta_5 Border_{ZAF,j} + \beta_6 Language_{ZAF,j} \quad (4.1)$$

$$+\beta_7 FTA_{ZAF,j,t} + \varepsilon_{ZAF,j,h,t},$$

where $EXP_{ZAF,j,h,t}$ is the value of exports for product *h*, from South Africa to importer *j* in year *t*. The model also includes the log GDP of the exporter (i.e., South Africa) and of each different importer *j* at time *t*,[91] and the log physical distance expressed in kilometres between South Africa and the destination country *j* ($dist_{ZAF,j}$). $Border_{ZAF,j}$, $Language_{ZAF,j}$ and $FTA_{ZAF,j,t}$ are three standard gravity dummy variables indicating whether South Africa and its trading partner *j* share a common border, speak the same language and belong to a common free trade agreement, respectively. To capture the displacement or crowding-out effect of China on South African exports, which is the main objective of the present analysis, I add to the model China's exports in the same product category *h* and to the same destination market *j* of South Africa's exports at time *t* ($EXP_{CHN,j,h,t}$). Finally, α is the constant and $\varepsilon_{ZAF,j,h,t}$ is the disturbance term.

This model aims to complement the one employed in the study published by Edward and Jenkins (2014) on South Africa. My work diverges from their contribution in a number of ways. First, I focus on the estimation of the level displacement effect on the intensive-intensive margins of trade; that is the effect of growing Chinese exports on the value of South African exports. Second, I extend the time period under analysis up until 2018. Third, the role of Hong Kong as a major conduit for mainland China's world exports is taken into account as in Greenaway et al. (2008) and Pham et al. (2017). Finally, I focus specifically on the exports of MHT products at a very detailed level of disaggregation (i.e., at 6-digit level), by looking at how this level displacement effect varies according to the specific sub-sector and destination market under consideration.

4.4.2 Data sources and expected results

Data on trade flows are directly from the UN Comtrade Database for the preferred specifications. I did not use data from the BACI dataset of CEPII since it aggregates SACU countries to harmonise import and export declarations over the entire period. However, South African trade data from the UN Comtrade Database also presents a major weakness in this

[91] In some additional unreported estimates (available upon request) I have also included the GDP per capita of South Africa and of the importing country *j* in the model. Results are in line with the expectations across all specifications (i.e., both have a positive impact on South African exports to country *j*) and do not affect the sign and/or the significance of the other regressors. I decided to focus on the model omitting these variables to improve readability of the main results.

respect: before 2010 data on South Africa's external trade published by SARS, and then incorporated into the UN Comtrade Database, covered only transactions between South Africa and countries outside SACU, therefore excluding trade between South Africa and Botswana, Lesotho, Namibia and Swaziland. Thus, I have been forced to exclude these four destination countries from the sample before 2010.

To build the dependent variable, I have used imports of country *j* from South Africa rather than exports from South Africa to country *j*. In fact, for a given country, imports are usually recorded with more accuracy than exports, since imports generate tariff revenues while exports do not (Greenaway et al., 2008).[92]

The data has been restricted to cover all trade flows of MHT manufacturing products originating from South Africa, over the 1995-2018 period. To do that, I have carried out the following steps. First, I have used very disaggregated trade data at the 6-digit product level of the Harmonized System (HS). Second, by means of the official correspondence tables, I have converted that data into the Standard International Trade Classification (SITC-Rev.3), maintaining the same level of product disaggregation. This transformation has allowed for the categorisation of exports into different technological classes (i.e., resource-based, low-, medium- and high-technology manufacturing products),[93] based on research conducted by Lall (2000).

Finally, I have removed from the sample all exports of primary goods, and resource-based and low-technology manufacturing products. The remaining products have been classified in seven medium-technology sub-groups (i.e., automotive, chemicals, plastics, iron and steel, engines and motors, non-electrical machinery, household appliances) and in six high-technology groups (i.e., pharmaceuticals, power-generating equipment, computer and office machines, electronics and telecommunications, electrical machinery, scientific instruments).[94] Aerospace and armament products have been excluded from the analysis, given the relatively modest Chinese global exports in these two sectors (Pham et al., 2017).

Data on countries' real GDP is from the World Bank World Development Indicators Database. Bilateral distances, measured as a simple distance in kilometres between the two

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[92] Nonetheless, it is important to acknowledge that import misreporting (especially under-invoicing) is a particularly important phenomenon in developing countries (Yang; 2008; Levin and Widell, 2014; Nitsch, 2017; Andreoni and Tasciotti, 2019).
[93] The list of SITC-Rev.3 goods grouped into the technological classes developed by Lall (2000) is available here: https://unctadstat.unctad.org/en/Classifications/DimSitcRev3Products_Ldc_Hierarchy.pdf.
[94] The detailed list of all the MHT products belonging to these 13 sub-sectors is presented in Table B.1 in Appendix B.

most populated cities of the exporter and the importer, come from the gravity database of CEPII. From the same data source, I have obtained the three bilateral dummy variables indicating whether South Africa and its trading partner *j* share a common border, speak the same language[95] and belong to a common free trade agreement, either bilateral or multilateral.

All the monetary variables in the dataset are reported in constant dollar (2015 = 100). As trade values are reported in current prices, I have used as deflators the importer's consumer price index (CPI) deflator from the IMF Data. When CPI was not available for specific countries, I have used the United States CPI. This was mainly the case for a number of low-income economies, especially in Africa (Giovannetti and Sanfilippo, 2009).

The final database includes only those MHT manufacturing products – excluding aerospace and armament goods – that were exported at the same time by South Africa and China to the same destination market over the 1995-2018 period. During this time frame South Africa and China have directly competed in 1040 MHT manufacturing products across 178 destinations.[96] Table 4.2 reports descriptive statistics and data sources of the variables used in this study.

Table 4.2. Descriptive statistics.

Variable	Obs.	Mean	Std. Dev.	Min	Max	Source
$\log(EXP)_{ZAF,j}$	495,180	10.457	2.127	6.850	21.729	UN Comtrade
$\log(EXP)_{CHN,j}$	495,180	12.969	2.873	6.847	24.723	UN Comtrade
$\log(GDP)_{ZAF}$	495,180	26.620	0.216	26.064	26.940	WDI
$\log(GDP)_{j}$	495,950	25.630	2.206	18.445	30.596	WDI
$\log(dist)_{ZAF,j}$	495,053	8.754	0.614	7.138	9.648	CEPII
$Border_{ZAF,j}$	495,053	0.040	0.195	0	1	CEPII
$Language_{ZAF,j}$	495,053	0.414	0.492	0	1	CEPII
$FTA_{ZAF,j}$	495,053	0.351	0.477	0	1	CEPII

According to the predictions of Equation 4.1, the South African exports of MHT products to a third market *j* depend on the four different groups of variables reported below.

$$\mathrm{EXP}_{ZAF,j} = \left[\overset{+}{\mathrm{GDP}_{ZAF} ; \mathrm{GDP}_j} \mid \overset{-}{\mathrm{GEO}_{ZAF,j}} \mid \overset{+}{\mathrm{CULT/POL}_{ZAF,j}} \mid \overset{+\,or\,-}{\mathrm{EXP}_{CHN,j}} \right]$$

Exports from South Africa to destination *j* are expected to rise with the GDP of both the exporter and the importer, *ceteris paribus*. Geographical proximity, namely a decreasing bilateral

[95] Specifically, the language dummy takes value 1 if the exporter and the importer have a common official or primary language, and 0 otherwise.
[96] Table B.2 in Appendix B reports all 178 of these importers.

distance and a common border between South Africa and the importer, should affect South African exports positively. It follows that the sign of the geographical distance variable is expected to be negative, while, on the other hand, the sign of the common border dummy is expected to be positive in my estimates. Cultural affinity between South Africa and country *j*, represented in my model by the common official language dummy variable, should influence South African exports to this destination positively. According to the predictions on the standard gravity model, trade policy also influences export performance. Thus, I expect South African exports to increase, or at least to remain constant, in those destination countries *j* guaranteeing preferential access to products originating from South Africa.

Finally, the expected sign of the explanatory variable of interest, namely Chinese exports of MHT products competing with South African ones in the same destination markets, is ambiguous (Kaplinsky and Messner, 2008; Kaplinksy and Morris, 2008). On the one hand, a negative sign can be expected, and thus the presence of a displacement or crowding-out effect, if the MHT products exported by South Africa and China are close substitutes to each other. On the other hand, if these are complementary, I might observe a positive coefficient for this variable.[97] Alternatively, the effect of Chinese exports might also not be statistically significant, meaning that they have no effect at all on South African exports. Results, however, might vary according to the specific destination market or MHT sub-sector considered in the analysis.

4.4.3 Estimation strategy

Previous work on China's crowding-out effect on other countries' exports has underlined the potential endogeneity of the explanatory variable of interest, $EXP_{CHN,j}$, that might correlate with the error term in Equation 4.1. This might be due to the presence of a common unobservable factor affecting at the same time the exports from China to a certain destination and those originating from South Africa and shipped to the same destination (Eichengreen et al., 2004 and 2007; Greenaway et al., 2008; Giovannetti and Sanfilippo, 2009; Pham et al., 2017).

In order to overcome such a correlation problem, and to avoid the related biases of OLS estimates in this case, empirical studies on the Chinese export displacement effect have generally adopted a two stages least squares (TSLS) estimation method, employing an appropriate set of instrumental variables.

[97] For instance, products might be complementary if they are imported and used as inputs to produce final goods (Pham et al., 2017).

Following this empirical literature, I have performed pooled estimates of Equation 4.1, based on the TSLS IV method.[98] As a first step, to justify the use of this estimation technique, I have tested the hypothesis that the explanatory variable of interest, namely the exports of MHT products from China ($EXP_{CHN,j}$), is endogenous. To this purpose, I have performed an endogeneity test (i.e., the Durbin-Wu-Hausman test), rejecting the null hypothesis of exogeneity of the regressor of interest in all the following estimates (see all tables, from 4.3 to 4.9 and from B.7 to B.12 in Appendix B). This result provides valuable feedback on the appropriateness of using the TSLS IV method instead of OLS in this case.

Following Eichengreen et al. (2004), Greenaway et al. (2008) and Pham et al. (2017), I instrument Chinese exports using two variables: (*i*) the distance between China and the importing country *j;* and (*ii*) China's real GDP. The hypotheses behind the gravity model and its predictions directly suggest the use of these variables as instruments, since they are two key determinants of Chinese exports to destination country *j*.

However, it is important to notice that the standard TSLS IV estimator is efficient only when errors are homoscedastic. Thus, as a second step, I have performed the Pagan-Hall test of heteroscedasticity for IV estimation. The results of the test confirm that, in this case, residuals are not homoscedastic (see Table 4.3 below). In the presence of heteroscedasticity, the generalised method of moments (GMM) estimator is more efficient than the standard TSLS IV estimator (Baum et al., 2007). Based on these considerations, I have decided to use a TSLS IV model based on the GMM estimator as in Greenaway et al. (2008) and Giovannetti and Sanfilippo (2009). Furthermore, to get efficient estimates in the very likely presence of intra-cluster correlation,[99] robust standard errors have been clustered at both product and country pairs (i.e., South Africa and importer *j*) level, following Giovannetti and Sanfilippo (2009).

The instruments chosen, namely the distance between China and the importing country *j* and China's real GDP, should satisfy two conditions: they should be relevant in the sense that they must be correlated with the endogenous variable; and they should be exogenous, meaning that they must be uncorrelated with the error term (Wooldridge, 2002). Distance between China and the importer country *j* strongly correlates with Chinese exports and it is plausibly

[98] Pooled estimates are more reliable in this case (Razmi and Blecker, 2008), since they have the advantage of increasing the degrees of freedom, reducing at the same time the collinearity of the independent variables (Baltagi, 2013). See also Giovannetti and Sanfilippo (2009) on this.

[99] In fact, in the case of Equation 4.1, the residuals' variance would probably be concentrated within certain specific groups of observations. The exports of a specific medium- or high-technology good from South Africa to a certain destination country *j* would probably be strongly correlated over time.

independent from other variables in the model.[100] China's real GDP is also strongly correlated with Chinese exports.

However, reasonable concerns can arise on its exogeneity. And, in fact, within the context of the Chinese model of export-led growth, the causality between GDP growth and increase in exports have probably run in both directions, not only from GDP to exports growth (Eichengreen et al., 2004). However, it is less plausible that in a given year the Chinese aggregate GDP is significantly influenced by its exports of a specific product *h* to a certain country *j*, as in my regression model. The very high values of the first-stage *F*-statistic support the relevance of the instruments in all the following estimates (see all tables, from 4.3 to 4.9 and from B.7 to B.12 in Appendix B). These instruments also pass the over-identification test based on the Hansen J-statistic.[101] The results of this test support the overall validity of this set of instruments.[102]

The IV approach described above seeks to solve the problem of correlation between the key regressor of interest and unobserved factors. However, it does not come without a price. As the distance between China and the destination country *j* varies only across the importer dimension, importer or importer-year fixed effects cannot be included as they correlate perfectly with the instrument. Similarly, China's real GDP only varies across the time dimension and thus I am unable to include a full set of year or importer-year fixed effects (Pham et al., 2017). The methodological choices made in this work to estimate the level effect of Chinese exports on South African exports have some clear advantages, but also some important weaknesses that must be taken into account when interpreting the results. These limitations are discussed extensively in Section 4.6, together with a number of possible ways forward for future research.

4.5 Econometric results

The main results are presented in what follows in separate sections (4.5.1) for the full sample, including all MHT products exported by South Africa to all destination countries between

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[100] Here, the rationale behind the use of the distance between China and the importing country *j* as an instrument is to focus on the remoteness of the destination market *j* from China as a way of identifying the impact of China's exports on the exports of South Africa in a specific sub-sample of products.

[101] When using the GMM estimator, instruments' orthogonality to the error term is reflected by the Hansen J-statistics (Greenaway et al., 2008).

[102] In some additional unreported estimates (available upon request) I have also tried to use only the distance between China and the importing country *j* as IV, to be able to include also year fixed effects in the model. However, in this case the IV is extremely weak in most of the specifications. See also Edwards and Jenkins (2014) on this (Edwards and Jenkins, 2014, p.S143, footnote 10).

1995 and 2018, (4.5.2) for each sub-sector within the MHT products' group and (4.5.3) for the different origin of the main trading partners of South Africa in terms of level of development and geographic area. Finally, Section 4.5.4 reports some additional checks and extensions.

4.5.1 Full sample

Table 4.3 shows the results and the main diagnostic tests from the estimation of Equation 4.1 for the full sample of MHT products where South Africa and China directly compete with each other in third markets. The first model specification reports OLS estimates, while TSLS results are presented in the second column. As expected, and as found by previous empirical works on the Chinese export displacement effect, results became negative (or less positive) when the instrumental variables were included in the specification (Eichengreen et al., 2004 and 2007; Greenaway et al., 2008; Giovannetti and Sanfilippo, 2009; Pham et al., 2017). In fact, as already mentioned in Eichengreen et al. (2004 and 2007), Greenaway et al. (2008) and Pham et al. (2017), this is precisely the type of upward bias I would expect in the OLS estimates, due to the presence of a common omitted shock such as, for example, a favourable change in the consumer sentiment worldwide. Such an unobservable factor should, in turn, positively affect both the exports of MHT products from China and from other countries (i.e., from South Africa in this particular case), introducing a positive correlation between the key regressor of interest and the error term.

Overall, the standard gravity-model variables perform nicely in both specifications. South Africa's exports tend to rise with its GDP (i.e., size of export supply) and with the GDP of the importing country (i.e., size of import demand). As expected, distance has a negative effect on South African exports, while sharing a common language or a common border with the trading partner boost them. And, in fact, with respect to this last point, South Africa's neighbouring countries are generally among its top 20 export destinations of MHT products over the entire period of interest. Moreover, together with some of its neighbours (Botswana, Lesotho, Namibia and Swaziland), South Africa also belongs to, and dominates the internal exports of, SACU. The presence of a free trade agreement between South Africa and its trading partners does not appear to influence its exports of MHT products positively. Results in the second column of Table 4.3 suggest that its impact is negative, although only weakly significant. This might point to the fact that some of these trade agreements only partially cover MHT products or that they are not effectively implemented.

As far as the main variable of interest is concerned, over the 1995–2018 period the growth of Chinese exports of MHT goods appears to have displaced South African exports to third markets in the same product categories. Specifically, a 1% increase in Chinese exports of MHT products leads to a 0.16% decline in South African exports in the same sectors. The results of this first exploratory estimation on the full sample suggest that, overall, Chinese MHT exports have been substitutes for those of South Africa rather than complementary. This is partly consistent with the findings of Pham et al. (2017), who show that Chinese high-technology exports are complementary to those of advanced countries, while they have displaced the exports of its developing competitors, such as India, Brazil, Mexico, Malaysia, Thailand and Vietnam, in most high-technology products.

Table 4.3. China's export displacement effect analysis on the full sample.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$	
Specification	(1)	(2)
Estimation method	OLS	TSLS/GMM
$\log(EXP)_{CHN,j,h,t}$	0.043***	–0.164***
	(0.003)	(0.006)
$\log(GDP)_{ZAF,t}$	0.125***	0.354***
	(0.013)	(0.015)
$\log(GDP)_{j,t}$	0.189***	0.390***
	(0.005)	(0.007)
$\log(dist)_{ZAF,j}$	–1.121***	–0.969***
	(0.021)	(0.024)
$Border_{ZAF,j}$	0.867***	0.962***
	(0.053)	(0.060)
$Language_{ZAF,j}$	0.398***	0.381***
	(0.018)	(0.019)
$FTA_{ZAF,j,t}$	0.028	–0.036*
	(0.018)	(0.019)
Constant	1.022***	1.455***
	(0.403)	(0.417)
Observations	492,823	492,823
R-squared	0.124	-
First-stage *F*-stat. [*p*-value]	-	5123.50 [0.000]
Endogeneity test. [*p*-value]	-	1770.25 [0.000]
Pagan-Hall [*p*-value]	-	3209.81 [0.000]
Hansen *J*-stat. [*p*-value]	-	0.168 [0.681]

Notes:

1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*.
2. Log GDP of China and log distance from China to country *j* are used as IV in (2).
3. Standard errors in parentheses are clustered at both product and exporter-importer level.
$^{*} p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$
Source: Author's calculations using UN Comtrade 6-digit product-level data.

However, the results of estimates in Table 4.3, covering all MHT exports, might hide very different patterns at the disaggregated level. In particular, the Chinese export displacement effect can vary from one sub-sector to another, and from one group of importers to another. In what follows, I focus on these two sources of heterogeneity.

4.5.2 Heterogeneity by sub-sectors

As a second exercise, I also estimate Equation 4.1 on data disaggregated by sub-sectors. While still employing 6-digit product-level data, I run separate regressions for exports of goods belonging to each different MHT sub-sector.[103] IV results for these estimations are reported in Table 4.4 for seven medium-technology sub-sectors (i.e., automotive, chemicals, plastics, iron and steel, engines and motors, non-electrical machinery and household appliances) and in Table 4.7 for six high-technology sub-sectors (i.e., pharmaceuticals, power-generating equipment, computer and office machines, electronics and telecommunications, electrical machinery and scientific instruments).[104] Tables 4.5 and 4.6 report more detailed findings based on the major sub-groups included in the non-electrical machinery sector, which is the industry with the highest number of observed products where South Africa and China compete with each other in third markets over the 1995-2018 period. Tables B.3 to B.5 in Appendix B report the corresponding OLS estimates.

4.5.2.1 Medium-technology sub-sectors

Table 4.4 shows results for exported goods belonging to seven medium-technology sectors (i.e., automotive, chemicals, plastics, iron and steel, engines and motors, non-electrical machinery and household appliances). The standard gravity-model control variables are generally significant and have the expected sign. However, consistent with the results from Table 4.3 above, I do not find any convincing evidence of the effectiveness of free trade agreements in enhancing South African exports of medium-technology products to its trade

[103] Separate regression analyses to capture sectoral heterogeneity are quite common within applied evolutionary studies on trade (for an example see Dosi et al., 2015a, pp. 1803-1806, Figures 4.5 to 4.9).
[104] I am well aware that the separation between medium- and high-technology manufacturing products proposed in Lall's classification (Lall, 2000) is quite problematic and blurred. In fact, within each product group there can be a huge variety in terms of quality and sophistication. This classification is used here mainly to organise the empirical results in a relatively more structured manner.

partners. In the case of automotive, the positive effect of sharing a free trade agreement is only very weakly significant, while with regard to chemicals, and iron and steel, it is negative.

The negative and significant effect of the variable of interest is confirmed in all the separate regressions, meaning that over the period of interest, the increase of Chinese exports of medium-technology goods has displaced South African exports to third markets in the same product categories. However, some heterogeneity is detected in terms of magnitude and degree of significance. For products belonging to certain sub-sectors, such as iron and steel, household appliances, chemicals, and engines and motors, the displacement effect has been larger than the effect for the full sample of MHT exports. This is particularly the case for the group of iron and steel products, where a 1% increase in Chinese exports leads to a 0.73% decline in South African exports. This result fully reflects the significant impact that Chinese competition had on the South African steel manufacturing industry, in terms of both its production and export performance, already emphasised elsewhere (Van der Merwe and Kleynhans, 2017; Zalk, 2017; Rustomjee et al., 2018). Products belonging to the non-electrical machinery industry, and to the automotive and plastics sectors, report a below-average negative coefficient for the indicator of Chinese exports. In the case of automotive and plastics products the coefficient is much lower relative to all the other medium-technology sectors considered in Table 4.3, and only weakly significant, meaning that in those industries the Chinese displacement effect on South African exports has been less marked. With reference to the non-electrical machinery industry, however, the displacement effect is still relatively strong and highly statistically significant: a 1% increase in Chinese exports leads to a 0.13% decline in South African exports. This result deserves further analysis, given the very large number of observed products within the non-electrical machinery industry where South Africa and China competed with each other in third markets over the period of interest (i.e., 162,983).

Table 4.4. Chinese export displacement effect analysis on medium-technology sub-sectors.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$						
Sector	Automotive	Chemicals	Plastics	Iron and steel	Engines and motors	Non-electrical machinery	Household appliances
Estimation method	TSLS/GMM	TSLS/GMM	TSLS/GMM	TSLS/GMM	TSLS/GMM	TSLS/GMM	TSLS/GMM
$\log(EXP)_{CHN,j,h,t}$	–0.065**	–0.201***	–0.072**	–0.731***	–0.183***	–0.131***	–0.241***
	(0.030)	(0.029)	(0.021)	(0.054)	(0.044)	(0.008)	(0.038)
$\log(GDP)_{ZAF,t}$	0.284***	0.322***	0.198***	0.318***	0.290**	0.407***	0.313***
	(0.069)	(0.043)	(0.053)	(0.041)	(0.103)	(0.021)	(0.072)
$\log(GDP)_{j,t}$	0.383***	0.406***	0.263***	0.387***	0.549***	0.341***	0.461***
	(0.039)	(0.022)	(0.026)	(0.019)	(0.050)	(0.011)	(0.050)
$\log(dist)_{ZAF,j}$	–1.174***	–1.084***	–1.032***	–0.686***	–0.970***	–0.952***	–0.885***
	(0.124)	(0.072)	(0.099)	(0.147)	(0.150)	(0.038)	(0.156)
$Border_{ZAF,j}$	0.878***	1.254***	0.729***	1.230***	0.900**	0.884***	0.889**
	(0.313)	(0.177)	(0.204)	(0.292)	(0.432)	(0.095)	(0.366)
$Language_{ZAF,j}$	0.214**	0.324***	0.403***	0.066	0.306**	0.326***	0.377***
	(0.018)	(0.055)	(0.076)	(0.114)	(0.138)	(0.030)	(0.119)
$FTA_{ZAF,j,t}$	0.215*	–0.298***	0.027	–0.224*	–0.113	–0.056	0.199
	(0.118)	(0.063)	(0.083)	(0.132)	(0.126)	(0.029)	(0.121)
Observations	25,359	57,855	30,162	18,457	10,149	162,983	12,027
First-stage *F*-stat.	617.71	636.50	1188.77	199.97	238.23	2836.62	302.52
[*p*-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Endogeneity test.	76.21	152.73	15.88	167.85	47.08	988.23	104.240
[*p*-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Hansen *J*-stat.	1.765	2.613	1.602	0.965	1.323	0.254	0.470
[*p*-value]	[0.186]	[0.106]	[0.207]	[0.327]	[0.250]	[0.614]	[0.493]

Notes: 1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*. 2. Log GDP of China and log distance from China to country *j* are used as IV in all columns. 3. Standard errors in parentheses, clustered at both product and exporter-importer level. 4. Constant term omitted. 5. Results of the Pagan Hall test omitted, but H_0 of homoscedasticity rejected in all estimates. $^{*} p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$.
Source: Author's calculations using UN Comtrade 6-digit product-level data.

A digression on the major non-electrical machinery sub-groups

Table 4.5 shows the estimates for the three major sub-sectors within the non-electrical machinery industry: general purpose machinery, special purpose machinery, and metalworking machines and machine tools. The focus on this further disaggregation allows some light to be shed on the heterogeneity characterising this group of medium-technology products in terms of Chinese displacement of South African exports. Metalworking machines and machine tools are the most affected by Chinese competition in third markets: a 1% increase in Chinese exports leads to a 0.30% decline in South African exports. This effect is relatively less marked for products belonging to the general and special purpose machinery sectors. In particular, the South African exports of special purpose machinery and equipment are the least affected by Chinese competition.

This result might be linked to the existence in South Africa of very strong local capabilities in certain specific niches of the special purpose machinery industry. Specifically, South Africa plays host to a variety of foreign and domestic mining equipment producers, with strong and particularly advanced capabilities in offering products and services in certain fields, such as deep level mining and areas related, to their demanding clients in the region and all over the world (Kaplan, 2012).

On the basis of this premise, I replicate the estimates on the sub-group of South African exports of products belonging to the mining machinery industry. As shown in Table 4.6, contrary to the rest of the products belonging to the special purpose machinery industry, South African exports of mining machines and related parts and components have not been affected negatively by Chinese competition between 1995 and 2018. However, while over the whole 1995-2018 period, South Africa-based mining equipment producers and exporters have proved to be sufficiently competitive in third markets relative to the Chinese exports, the trend does appear to have turned negative more recently, in the aftermath of the GFC (see Section 4.5.4 and Chapter 5 for further details on this).

Table 4.5. Chinese export displacement effect analysis on major non-electrical machinery sub-sectors.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$		
Sector	General purpose machinery	Special purpose machinery	Metalworking machines and machine tools
Estimation method	TSLS/GMM	TSLS/GMM	TSLS/GMM
$\log(EXP)_{CHN,j,h,t}$	–0.127***	–0.081***	–0.302***
	(0.012)	(0.015)	(0.029)
$\log(GDP)_{ZAF,t}$	0.329***	0.500***	0.591***
	(0.026)	(0.041)	(0.068)
$\log(GDP)_{j,t}$	0.376***	0.244***	0.483***
	(0.015)	(0.019)	(0.033)
$\log(dist)_{ZAF,j}$	–1.133***	–0.835***	–0.359***
	(0.047)	(0.072)	(0.091)
$Border_{ZAF,j}$	1.064***	0.802***	0.970***
	(0.117)	(0.167)	(0.162)
$Language_{ZAF,j}$	0.465***	0.172**	0.006
	(0.038)	(0.055)	(0.06)
$FTA_{ZAF,j,t}$	0.061	–0.179**	–0.187**
	(0.038)	(0.051)	(0.064)
Observations	99,420	47,472	16,091
First-stage *F*-stat.	2913.08	1622.07	471.95
[*p*-value]	[0.000]	[0.000]	[0.000]
Endogeneity test.	519.02	284.51	151.97
[*p*-value]	[0.000]	[0.000]	[0.000]
Hansen *J*-stat.	0.370	0.104	0.162
[*p*-value]	[0.523]	[0.747]	[0.673]

Notes:

1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*.
2. Log GDP of China and log distance from China to country *j* are used as IV in all columns.
3. Standard errors in parentheses are clustered at both product and exporter-importer level.
4. Constant term omitted.
5. Results of the Pagan Hall test omitted, but the H_0 of homoscedasticity is rejected in all estimates.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Author's calculations using UN Comtrade 6-digit product-level data.

Table 4.6. Chinese export displacement effect analysis on mining and other special purpose machinery.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$	
Sector	Mining machinery	Other special purpose machinery
Estimation method	TSLS/GMM	TSLS/GMM
$\log(EXP)_{CHN,j,h,t}$	–0.043	–0.098***
	(0.147)	(0.017)
$\log(GDP)_{ZAF,t}$	0.715***	0.421***
	(0.093)	(0.044)
$\log(GDP)_{j,t}$	0.261***	0.254***
	(0.037)	(0.021)
$\log(dist)_{ZAF,j}$	–1.234***	–0.723***
	(0.152)	(0.078)
$Border_{ZAF,j}$	0.760***	0.805***
	(0.341)	(0.177)
$Language_{ZAF,j}$	0.350**	0.171**
	(0.117)	(0.060)
$FTA_{ZAF,j,t}$	–0.186	–0.228**
	(0.114)	(0.060)
Observations	9,091	38,381
First-stage *F*-stat.	438.39	1211.18
[*p*-value]	[0.000]	[0.000]
Endogeneity test.	52.52	213.96
[*p*-value]	[0.000]	[0.000]
Hansen *J*-stat.	0.962	0.203
[*p*-value]	[0.323]	[0.682]

Notes:

1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*.
2. Log GDP of China and log distance from China to country *j* are used as IV.
3. Standard errors in parentheses are clustered at both product and exporter-importer level.
4. Constant term omitted.
5. Results of the Pagan Hall test omitted, but H_0 of homoscedasticity has been rejected.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Author's calculations using UN Comtrade 6-digit product-level data.

4.5.2.2 High-technology sub-sectors

I now turn to the assessment of the Chinese displacement effect on South African exports of high-technology products (i.e., pharmaceuticals, power-generating equipment, computer and office machines, electronics and telecommunications, electrical machinery and scientific instruments) over the whole 1995-2018 period. It is interesting to note that the negative and significant effect of the variable of interest is confirmed in all the separate regressions in Table 4.7. The most affected sub-sectors are (in descending order) electrical machinery, computer and office machines, power-generating equipment, and electronics and telecommunications. In these industries, a 1% increase in Chinese exports is associated with a decline in South African exports ranging from 0.14% to 0.21%.

The Chinese displacement effect on South African exports is less marked for products belonging to the pharmaceutical industry and to the scientific and precision instruments sector. In those cases, the coefficient of the key variable of interest is relatively lower and only weakly significant. As in the previous estimates, control variables are generally significant and have the expected sign. Again, the coefficient of the free trade agreements dummy is generally not significant. A very weak positive effect is found only for exports of power-generating equipment, and computer and office machines.

Table 4.7. Chinese export displacement effect analysis on high-technology sub-sectors.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$					
Sector	Pharmaceuticals	Power generating equipment	Computer and office machines	Electronics and telecommunications	Electrical machinery	Scientific instruments
Estimation method	TSLS/GMM	TSLS/GMM	TSLS/GMM	TSLS/GMM	TSLS/GMM	TSLS/GMM
$\log(EXP)_{CHN,j,h,t}$	–0.134*	–0.178***	–0.191***	–0.144***	–0.210***	–0.091**
	(0.032)	(0.017)	(0.041)	(0.026)	(0.031)	(0.027)
$\log(GDP)_{ZAF,t}$	0.217**	0.400***	0.423***	0.380***	0.200**	0.198***
	(0.077)	(0.039)	(0.036)	(0.067)	(0.058)	(0.036)
$\log(GDP)_{j,t}$	0.360***	0.409***	0.478***	0.385***	0.496***	0.354***
	(0.046)	(0.022)	(0.041)	(0.030)	(0.034)	(0.019)
$\log(dist)_{ZAF,j}$	–0.888***	–1.247***	–1.137***	–0.981***	–0.989***	–0.892***
	(0.122)	(0.070)	(0.134)	(0.113)	(0.100)	(0.060)
$Border_{ZAF,j}$	0.529	1.140***	1.165**	0.619**	1.270***	0.763***
	(0.350)	(0.192)	(0.385)	(0.283)	(0.262)	(0.161)
$Language_{ZAF,j}$	0.251**	0.625***	0.738***	0.361	0.559***	0.419***
	(0.109)	(0.057)	(0.096)	(0.087)	(0.081)	(0.047)
$FTA_{ZAF,j,t}$	–0.143	0.094*	0.174*	–0.094	0.070	0.045
	(0.116)	(0.051)	(0.092)	(0.081)	(0.077)	(0.043)
Observations	13,188	47,125	30,162	23,494	23,250	47,633
First-stage F-stat.	158.59	1084.63	154.37	479.93	335.77	1218.48
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Endogeneity test.	32.72	374.48	71.99	165.18	107.99	205.51
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Hansen J-stat.	0.508	1.613	1.824	1.565	1.223	0.797
[p-value]	[0.476]	[0.197]	[0.176]	[0.224]	[0.282]	[0.372]

Notes: 1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*. 2. Log GDP of China and log distance from China to country *j* are used as IV in all columns. 3. Standard errors in parentheses, clustered at both product and exporter-importer level. 4. Constant term omitted. 5. Results of the Pagan Hall test omitted, but H_0 of homoscedasticity rejected in all estimates. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Source: author's calculations using UN Comtrade 6-digit product-level data.

4.5.3 Heterogeneity by different groups of trading partners

This sub-section sheds some light on whether the Chinese displacement effect on South African exports of MHT products over the 1995-2018 period has been equally distributed among different groups of destination countries or if, on the contrary, some specific markets have been more seriously affected relative to others.

IV results for disaggregated by groups of destination countries are reported in Table 4.8. Tables B.6 in the Appendix B reports the corresponding OLS estimates. The first two columns of Table 4.8 show results for two sub-samples of destination countries: OECD and non-OECD economies. While evidence of a Chinese displacement effect is detected in both cases, the impact is stronger for South African exports directed to non-OECD countries.

The third column of Table 4.8 reports IV results for a sub-group of OECD countries, namely Germany, United States, United Kingdom and Japan, which are the main export destinations for South African MHT products across the 1995-2018 period as a whole. While evidence of a Chinese displacement effect is found also in this case, its impact is lower than the average effect detected for the broader group of OECD countries.

On the contrary, a positive, significant and relatively stronger effect is found for South Africa's exports of MHT products shipped to other African countries and, more specifically, to other sub-Saharan ones. Overall, the rise of China's exports of MHT goods poses significant challenges to South Africa's exports of the same product categories directed to other developing countries and, particularly, to other African and sub-Saharan economies.

The standard gravity-model control variables are generally significant and have the expected sign. Interestingly, and partly in contrast with previous estimates, the coefficient of the free trade agreements dummy is always significant when splitting the sample of destination countries into sub-groups. On the one hand, a negative and rather weakly significant effect is detected in the case of South African exports directed to OECD countries and to a sub-set of them (i.e., Germany, United States, United Kingdom and Japan). On the other hand, the presence of free trade agreements between South Africa and its partners did appear to strongly and positively enhance South African exports of MHT products to other sub-Saharan countries, to African ones more generally, and to the broader group of developing countries. This might point to the fact that these South-South and intra-regional agreements involving South Africa generally ensure a better coverage of MHT products and/or are more easily implemented.

Table 4.8. Chinese export displacement effect analysis on different groups of destination countries.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$				
Destination	OECD	Non-OECD	Main partners§	Africa	Sub-Saharan Africa
Estimation method	TSLS/GMM	TSLS/GMM	TSLS/GMM	TSLS/GMM	TSLS/GMM
$\log(EXP)_{CHN,j,h,t}$	–0.135***	–0.202***	–0.119***	–0.331***	–0.353***
	(0.011)	(0.010)	(0.020)	(0.023)	(0.025)
$\log(GDP)_{ZAF,t}$	0.272***	0.380***	0.380***	0.402***	0.408***
	(0.024)	(0.016)	(0.050)	(0.023)	(0.023)
$\log(GDP)_{j,t}$	0.461***	0.391***	0.477***	0.452***	0.450***
	(0.016)	(0.010)	(0.090)	(0.024)	(0.024)
$\log(dist)_{ZAF,j}$	–0.323**	–0.712***	–1.513***	–0.713***	–0.683***
	(0.135)	(0.030)	(0.374)	(0.068)	(0.072)
$Border_{ZAF,j}$	-	0.920***	-	0.870***	0.918***
		(0.060)		(0.082)	(0.082)
$Language_{ZAF,j}$	0.298***	0.308***	0.335***	0.345***	0.340***
	(0.045)	(0.021)	(0.091)	(0.035)	(0.036)
$FTA_{ZAF,j,t}$	–0.074**	0.366***	–0.094**	0.382***	0.373***
	(0.033)	(0.033)	(0.050)	(0.048)	(0.048)
Observations	167,173	325,650	45,086	185,676	172,102
First-stage *F*-stat.	3252.28	4119.25	1092.01	1070.64	896.44
[*p*-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Endogeneity test.	369.83	1300.01	131.90	944.55	809.99
[*p*-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Hansen *J*-stat.	1.279	2.356	1.221	1.947	1.821
[*p*-value]	[0.131]	[0.125]	[0.136]	[0.112]	[0.164]

Notes: 1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*. 2. Log GDP of China and log distance from China to country *j* are used as IV in all columns. 3. Standard errors in parentheses, clustered at both product and exporter-importer level. 4. Constant term omitted. 5. Results of the Pagan Hall test omitted, but H_0 of homoscedasticity rejected in all estimates. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Source: Author's calculations using UN Comtrade 6-digit product-level data.

4.5.4 Robustness checks and additional findings

To test the validity of these results, in this sub-section some robustness checks and additional analysis are performed. First, the sample is restricted to observations which have an export value higher than USD 10,000. In fact, small values are generally more likely to be subject to measurement errors. Results of this alternative full sample's estimates are reported in Table B.7 in Appendix B. These are qualitatively similar to those reported in Table 4.3 of Section 4.5.1, although the coefficient of the main variable of interest is slightly lower when considering IV estimates in Table B.7.

As a second extension, following Greenaway et al. (2008) and Pham et al. (2017), in some additional estimates I have substituted the Chinese exports variable, narrowly defined as the goods shipped directly from mainland China, with an indicator also including exports of MHT products originating from Hong Kong.[105] Results of this analysis are shown in Table B.8 in Appendix B. Comparing IV results from Table B.8 with those reported in Table 4.3, in Section 4.5.1, it is important to notice that, when exports from mainland China and Hong Kong are combined, the displacement effect on the full sample of South African exports of MHT products is slightly larger. In this case, indeed, a 1% increase in Chinese exports of MHT products leads to a 0.18% decline in South African exports to third markets in the same product categories. As already underlined by Greenaway et al. (2008), this result sheds some light on the key role of Hong Kong as a major conduit for mainland China's exports to the rest of the world.[106]

Finally, as in Pham et al. (2017), to account for the potential impact on the estimates of the GFC, I have excluded from the sample the years 2007, 2008 and 2009. Thus, I have replicated the regression analysis on the period before (i.e., 1995-2006) and after (i.e, 2010-2018) the GFC. The IV results for the full sample are reported in Table 4.9 below and show that, while Chinese MHT exports have reduced South African exports in the same product categories during both sub-periods, the displacement effect became stronger in the aftermath of the GFC.

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105 In their article, Pham et al. (2017) also include exports from Macau. In some unreported estimates (available upon request) I have performed the same empirical exercise, adding exports from Macau to those of mainland China and Hong Kong. Results are not appreciably different to when only mainland China's and Hong Kong's exports are taken into account.

106 According to the official data of the Trade and Industry Department of the government of Hong Kong, in 2019, around 55% of total re-exports from Hong Kong originated from China. Re-exported goods mainly belong to the following sub-sectors: electrical machinery, household appliances, electronics and telecommunication, and computer and office machines (TID, 2020).

Table 4.9. Chinese export displacement effect analysis before and after the GFC.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$		
Sub-period	1995-2018	1995-2006	2010-2018
Estimation method	TSLS/GMM	TSLS/GMM	TSLS/GMM
$\log(EXP)_{CHN,j,h,t}$	–0.164***	–0.124***	–0.183***
	(0.006)	(0.013)	(0.019)
$\log(GDP)_{ZAF,t}$	0.354***	0.241***	0.366***
	(0.015)	(0.022)	(0.020)
$\log(GDP)_{j,t}$	0.390***	0.359***	0.411***
	(0.007)	(0.010)	(0.015)
$\log(dist)_{ZAF,j}$	–0.969***	–1.019***	–0.958***
	(0.024)	(0.03)	(0.029)
$Border_{ZAF,j}$	0.962***	0.924***	0.970***
	(0.060)	(0.067)	(0.060)
$Language_{ZAF,j}$	0.381***	0.420***	0.339***
	(0.019)	(0.021)	(0.019)
$FTA_{ZAF,j,t}$	–0.036*	–0.051*	–0.070*
	(0.019)	(0.020)	(0.024)
Constant	1.455***	1.321***	1.587***
	(0.417)	(0.418)	(0.420)
Observations	492,823	165,264	250,549
R-squared	-	-	-
First-stage *F*-stat.	5123.50	2165.15	1188.15
[*p*-value]	[0.000]	[0.000]	[0.000]
Endogeneity test.	1770.25	437.41	381.78
[*p*-value]	[0.000]	[0.000]	[0.000]
Hansen *J*-stat.	0.168	0.368	0.768
[*p*-value]	[0.681]	[0.401]	[0.297]

Notes:
1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*.
2. Log GDP of China and log distance from China to country *j* are used as IV.
3. Standard errors in parentheses are clustered at both product and exporter-importer level.

$^{*} p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$

Source: Author's calculations using UN Comtrade 6-digit product-level data.

This additional analysis is also replicated at the disaggregated level for each MHT sub-sector and for different groups of destination countries. These IV results are shown in Tables B.9 to B.12 in Appendix B.

According to the results in Tables B.9, B.10 and B.11, it seems that the Chinese displacement effect has been generally higher in the aftermath of the GFC for all the sub-sectors considered, except for chemicals, plastics, computer and office machines, and scientific instruments. In a number of cases, the impact of Chinese exports of MHT products on South African exports in the same product categories was not statistically significant before the GFC, and turned negative and statistically significant only after it. This is exactly the case for exports of metalworking machinery and machine tools, mining machinery and equipment, automotive, pharmaceuticals, power-generating equipment, electronics and telecommunication, and electrical machinery. For these products, Chinese exports have become substitutes for those from South Africa more recently, in the aftermath of the GFC.

Results reported in Table B.12 do not reveal any significant difference in the effect of Chinese exports on South African ones directed to OECD countries before and after the GFC. Interestingly enough, however, these estimates suggest that Chinese and South African exports of MHT products directed to African countries in general and sub-Saharan ones in particular were complementary to each other during the 1995-2006 period and substitute from 2010 to 2018. This might point to the fact that from the mid-1990s until the mid-2000s Chinese and South African products were targeting very different segments of these markets, without competing with each other. More recently, through a gradual upgrading, Chinese goods directed to these destinations have started to secure a place in mid-price and premium segments, increasingly displacing exports from South Africa.

4.6 Conclusions

This chapter has analysed the Chinese export displacement effect on MHT products shipped from South Africa to other countries from 1995 to 2018. To some extent, this work is complementary, in terms of both its content and methods, to the only available econometric study so far on the Chinese export displacement effect in South Africa (Edward and Jenkins, 2014). I have employed an augmented gravity model, using detailed and very disaggregated data on exports at the 6-digit product level from UN Comtrade. Due to possible endogeneity and reverse causality issues, I have instrumented Chinese exports using China's real GDP and the distance between China and the destination country, following an identification strategy which is quite common in the empirical literature on the Chinese export displacement effect (Greenaway et al., 2008; Pham et al., 2017).

Based on this model, I have studied whether Chinese exports of MHT goods have displaced South African exports in the same product categories over the period under analysis. First, I have looked at the Chinese displacement effect on the full sample, including all MHT products exported by South Africa to all destination countries between 1995 and 2018. Second, I have run separate regressions for each sub-sector within the MHT group of products. Third, the analysis has been replicated for different groups of destination markets. Finally, the plausibility of the results has been tested through additional estimates, taking into account the most relevant trade flows, the role of Hong Kong as a gateway for mainland China's exports and the heterogeneity of the effect in different sub-periods (i.e., before and after the GFC).

The empirical results of this work shed some new light on the crowding-out effect of China on South African exports of MHT manufacturing goods. Overall, Chinese exports of MHT manufacturing products displaced competing South Africa exports in third countries from 1995 to 2018. Thus, in general, when China and South Africa competed in the same MHT product category and same destination market, an increase in China's exports was associated with a decrease in South African exports over the entire period under analysis.

As far as heterogeneity at the industry level is concerned, there is evidence of a statistically significant level displacement effect for almost all relevant MHT sub-sectors. This is particularly the case for exports of products belonging to the following industries: iron and steel, household appliances, metalworking machinery and machine tools, chemicals and electrical machinery. In addition, other products, such as power-generating equipment, computer and office machines, electronics and telecommunications, and general-purpose machinery, have suffered from Chinese competition in export markets. A relatively weak level displacement effect has been detected in the case of products belonging to sectors like automotive, plastics, pharmaceuticals and scientific instruments.

With respect to the heterogeneity at the level of the different groups of destination countries, I found that the level displacement effect varies relative to the specific sub-sample of importers considered. Interestingly, the rise of China's exports of MHT manufacturing goods poses significant challenges to South Africa's exports of the same product categories directed to non-OECD countries and, particularly, to other African and sub-Saharan economies. This evidence suggests that over the past two decades the increase and gradual upgrading of Chinese exports have contributed to the undermining of South Africa's competitiveness in other emerging economies and particularly its position as a regional economic power.

A number of robustness checks confirms the validity of the results. Additional estimates also reveal that when exports from mainland China and Hong Kong are combined, the displacement effect on the full sample of South African exports of MHT products is slightly larger. Furthermore, I find that the displacement effect has generally become stronger in the aftermath of the GFC.

These results have potentially important implications for South Africa and calls for integrated industrial policy actions aimed at promoting the upgrading of local capabilities in MHT manufacturing sectors, and at enhancing the competitiveness of South African exports in such product categories. Policy efforts should be directed, in particular, towards a number of MHT sectors where South Africa has already developed quite advanced export capabilities, like industrial machinery and automotive (Andreoni et al., 2021a).

Last, it is important to emphasise a number of important limitations of this study. These are listed and briefly discussed below.

First, the empirical strategy employed in the present study is particularly suitable for estimating the level displacement effect of Chinese exports on the intensive-intensive margins of trade and is based on a number of previous works (Eichengreen et al., 2004 and 2007; Greenaway et al., 2008; Giovannetti and Sanfilippo, 2009; Abu Hatab, 2017; Pham et al., 2017). Contrary to what Edwards and Jenkins (2014) did in their econometric study on South Africa, in this chapter I have not been able to estimate the relative displacement effect and I did not focus on the extensive margins of trade. Indeed, these could constitute relevant and interesting extensions, although some substantive changes in the empirical strategy and the dataset employed might be required (Edwards and Jenkins, 2014; Kong and Kneller, 2016; Elleby, 2018).

Second, because of the choices made about the empirical strategy and the estimation method, I could not include time and importer fixed effects in the model, and thus I could not control for those unobserved time and importer characteristics that could otherwise bias the results. Similarly, employing the IV estimation method adopted in this chapter, I have not been able to include a set of country-year fixed effects to take into account time-varying multilateral resistance (Anderson and Van Wincoop, 2003; Baldwin and Taglioni, 2006). In a recent unpublished working paper Elleby et al. (2018) propose a novel methodology to estimate the level displacement effects, in addition to the relative one, using a gravity model with country-year, industry-year and country-pair fixed effects. An extension along those lines might also be extremely insightful. However, again, the entire empirical strategy and the dataset used should be adapted accordingly.

Third, as already pointed out at the end of Section 4.2.2, in the present study export volumes are those recorded when products are shipped across the border of the exporting country (i.e., China and South Africa in this case). The availability of detailed information on the domestic and foreign value added embodied in each country's exports for a sufficient number of years and at a very disaggregated product level would improve significantly our understanding of the actual competition dynamics between these (and other) emerging economies along GVCs.

Finally, the present econometric study has allowed an overall assessment of the Chinese displacement effect for South African exports of MHT manufacturing products to be carried out. However, although conducted at a very disaggregated level, this analysis does not allow a number of key aspects to be investigated more deeply. These might include, for instance, the actual GVCs competition dynamics already mentioned; the quality- and cost-based differences between products exported by China, South Africa and other competitors to third destinations; the specific drivers of competition stemming from Chinese exports relative to that from other players in specific sectors; the evolving trajectories of China and its firms along MHT GVCs; whether and how the rise of Chinese competition has interacted with other structural transformations affecting many global industries over the past two decades; and what the strategic responses of South Africa-based producers, both domestic- and foreign-owned, have been to such competitive pressure and structural dynamics in certain key MHT industries.

To deal with a number of these limitations and with some of the weaknesses of the firm-level econometric analysis conducted in the previous empirical chapter, Part II of this thesis focuses on a detailed sectoral case study largely based on primary data collected through semi-structured interviews. The mining equipment and machinery industry has been chosen for its historical and strategic relevance within the South African economy. Furthermore, as underlined by the econometric results in this chapter, this medium-technology industry seems to have followed an interesting trajectory over the past two decades, which requires further investigation. In fact, although during the period 1995-2006 South Africa-based mining equipment producers proved to be sufficiently competitive in third markets relative to Chinese exports, the trend does appear to have turned negative more recently, between 2010 and 2018, in the aftermath of the GFC (see Table B.10 in Appendix B on this).

PART II

The sectoral case study evidence

Chapter 5

Capabilities, upgrading and value capture in GVCs: Evidence from local mining equipment firms in South Africa and their main foreign competitors

5.1 Introduction

The mining equipment sector has been a cornerstone of industrial development in South Africa since the late 1960s, when the process of mining mechanisation accelerated (Black and Edwards, 1957; Rustomjee, 1993). Today, it represents the most relevant and technologically sophisticated segment of the broader special purpose machinery industry in the country, and contributes significantly to overall South African manufacturing production and employment (Kaplan, 2012; Lydall, 2009; Walker and Minnitt, 2006). However, during the past decade the sector has experienced a remarkable stagnation in global competitiveness, driven by the depressed price environment in many hard commodities markets, the decline in domestic mining production, and the limited ability of indigenous OEMs to take full advantage of the new windows of opportunity opened up for innovation, diversification and linkages in mining regions (Morris et al., 2012).

This is reflected in a series of observable trends within the industry: first, the small number of locally owned export champions actively orchestrating and nurturing the transformation of the domestic value chain; second, the increasing dominance in domestic and regional markets of a few multinational equipment producers with only limited local manufacturing and engineering footprints; and, third, the significant level of imports, particularly from China, along all stages of the domestic and regional value chain. In more general terms, the current competitive positioning of this advanced sector mirrors the broadly stagnating economic situation faced by South Africa, brought onto a premature deindustrialisation trajectory and trapped in its middle-income status (Andreoni and Tregenna, 2020).

Against this background, this chapter explores the main reasons behind the ongoing marginalisation of South Africa as a strategic location for production and innovation of mining-related equipment, despite the strong core technological and production-related capabilities of its domestic supplier base. By analysing the role of dominant multinational incumbent firms and powerful emerging Chinese actors in shaping the structure of the global mining machinery industry, it identifies the barriers faced by South African firms in their attempts to maximise value capture from upgrading and consolidate their competitive position, moving from local to global. Adopting a detailed micro-level perspective, the study focuses on two aspects not sufficiently considered by recent contributions at the interface between the innovation and the GVC literature on the new opportunities for upgrading associated with mining activities in emerging economies (Pietrobelli et al., 2018). First, it examines the role played by the changing organisational structure of the global mining industry and the related backward sectors supplying critical inputs. Second, within this evolving competitive scenario, it stresses the importance for local suppliers in emerging economies to develop and strengthen a set of key sectoral GVC-specific resources and capabilities, complementary to the purely technological ones (i.e., technical mastery in terms of product conception, design and development), to maximise value capture and enter into fruitful bargaining processes with the chain's leaders.

In doing so, this analysis builds on recent advances within and beyond the GVC literature.[107] First, it reviews studies on the changing organisational structures and the evolving competitive landscapes in global industries, underlining how these dynamics might affect firms in developing countries (Nolan et al., 2008; Williamson and Zeng, 2009; Fessehaie, 2012a; Dallas et al., 2019; Horner and Nadvi, 2018; Raj-Reichert, 2019a and 2019b). Second, it expands on micro-level studies on technological capability building in emerging economy firms within the context of globalised industries (Morrison et al., 2008; Whitfield et al., 2020; Figueiredo et al., 2020). This is done by taking into account insights from corporate management and international business studies (Teece, 1986 and 2014; Teece et al., 1997), and recent GVC contributions acknowledging the importance for firms of developing resources and capabilities complementary to the core technological ones to maximise value capture from upgrading efforts (Sako and Zylberberg, 2019; Whitfield et al., 2020). In sum, this chapter aims to advance the literature on supplier firm agency (or power) by focusing on strategies and processes for building the capabilities of both foreign and local firms to upgrade and capture value along the

[107] There is an ongoing dispute between the GVC and the GPN analytical frameworks around their respective strengths and weaknesses. However, for the purpose of this chapter I view the GVC and the GPN formulations as expressing an essentially common perspective for analysing international production systems, while acknowledging the fundamental differences between them, including in their intellectual and disciplinary origins (Bair, 2009; Parrilli et al., 2013). The GVC concept is used in the rest of the chapter not to land on one side or other of this debate on the most appropriate framework, but rather as a shorthand term of reference in relation to the dynamics of contemporary globalisation. When differences between the two frameworks are relevant to the present analysis, a distinction between them is clearly made in the text.

value chain. By applying such theoretical considerations to the specific case of the mining equipment industry, the empirical part of this chapter develops along two main directions.

First, in an attempt to open the black box of foreign supplier firm agency in extractive GVCs, it examines the reorganisation trajectories taking place within the global mining equipment sector in the last two decades. It is argued that these have been triggered by tremendous processes of concentration and consolidation among incumbent transnational first-tier suppliers (TFSs)[108] on the one side, and on the other side by the entry and upgrading of new manufacturers, particularly from China. Such restructuring dynamics and the associated capabilities and strategies of these foreign suppliers have prompted the emergence of multiple patterns of interactions, chain polarity[109] and power configurations among them, buyers and middlemen, along the *vertical* GVC dimension. These trajectories, in turn, have important implications on *horizontal* competition, upgrading and value capture opportunities at the first-tier level, especially for local equipment producers from developing countries and, in this particular case, from South Africa.

Second, using a case study methodology, the chapter identifies the main set of capabilities of local South African suppliers and the upgrading strategies they have adopted in light of the reorganisation dynamics which are reshaping the competitive environment in the industry. Specifically, I first describe the patterns and quality of the interactions prevailing within the South African mining equipment industry among key actors. Second, I explore the nature of the upgrading trajectories of the suppliers, with emphasis on the internal and external factors that limit their agency, as well as their further growth and expansion. In particular, I underline how, despite a strong legacy in design, engineering and manufacturing capabilities, many South African companies have not been able to consolidate their competitive position, moving from local to global, especially in the value chains with the highest growth potential, which are those dominated by major mining companies. This, in turn, leads me to assess the relevance of developing a set of key sectoral GVC-specific capabilities, including specialised and co-specialised resources complementary to the firm's core technological ones, to maximise value capture from upgrading efforts. These elements are, indeed, the critical determinants of the competitive ownership-specific advantages of TFSs and emerging competitors, in comparison with local producers.

108 The term 'transnational first-tier suppliers' was introduced by Raj-Reichert (2019a) to discuss the increasing importance of a small group of multinational companies in electronics, automotive and apparel GVCs.
109 The 'polarity' is defined by the number of functional nodes where power-in-the-chain resides (Ponte and Sturgeon, 2014) and it is determined by which actor (or actors) drives the value chain.

This study is based on primary and secondary research. Primary data was collected through 49 semi-structured interviews and two focus groups conducted with industry representatives in South Africa in 2019. Secondary research is based on available data, specialised magazines, and reports from companies, industry associations, think tanks and government agencies.

The chapter is organised as follows. Section 5.2 reviews recent contributions on the new opportunities for innovation and linkages development associated with mining activities in emerging economies, underlining a number of key aspects not covered in depth so far. To fill these gaps, Section 5.3 develops a novel GVC interpretative framework 'augmented' by recent advances in research on the changing organisational structures characterising global industries, and insights acknowledging the importance of capabilities complementary to core technological ones to capture value from upgrading along GVCs. In Section 5.3, this framework is operationalised within the context of the global mining equipment industry and serves as a starting point for the formulation of specific research questions. Section 5.4 describes primary and secondary data, and the methods applied in this study. This is followed by a discussion of the empirical evidence. Section 5.5 looks at the ongoing restructuring trajectories characterising the global mining equipment industry, with special reference to the evolving role of key TFSs and emerging Chinese manufacturers. This section (5.5) also elaborates on the implications of such reorganisation dynamics for the agency of local equipment manufacturers in developing countries. Section 5.6 addresses the experiences of the South African suppliers interviewed to understand how they have navigated the changing competitive landscape, analysing the factors favouring or hindering this adaptation process. Section 5.7 concludes, highlighting a number of contributions made to the literature and directions for future research.

5.2 Extractive industries and upgrading in developing countries: what is missing?

Departing from the 'natural resource curse' hypothesis, recent studies within the innovation literature argue that extractive industries might provide emerging economies with a platform for engaging and upgrading in backward knowledge-intensive activities (Perez, 2010; Andersen, 2012, Morris et al., 2012; Urzua, 2013; Marin et al., 2015; Crespi et al., 2018).[110] According to this literature, the opportunities associated with mining activities relate to the changing volumes, patterns and requirements of demand, the advances in science and

[110] This is also widely referred to as the literature on knowledge-intensive mining suppliers (KIMS).

technology, the local specificities of the geological conditions characterising mineral deposits and the increasingly stringent environmental regulations (Pietrobelli et al., 2018; Molina, 2018; Aron and Molina, 2020).

Detailed case studies conducted in a number of emerging economies in Latin America (Pietrobelli et al., 2018; Stubrin, 2017; Molina 2018; Aron and Molina, 2020) and sub-Saharan Africa (Morris et al., 2012; Kaplan, 2012) show that this potential has been exploited only by a limited number of local companies with strong core technological and production-related capabilities.[111] These firms have successfully entered dynamic and knowledge-intensive segments of the value chain by adopting different strategies: by producing high-quality and customised equipment well-suited for the domestic geological conditions; by forging partnerships with global suppliers; by developing new technologies targeting local market niches and by introducing green innovations. However, these studies also stress that upgrading remains limited to a few companies (Pietrobelli et al., 2018), with others generally lacking the market-access capabilities to further consolidate their position, and to move from local to global (Urzua, 2012; Molina, 2018; Stubrin, 2017). Moreover, in the case of the South African mining input cluster, despite a number of successful cases at the individual firm-level, evidence (Kaplan, 2012; Morris et al., 2012) shows an overall tendency for domestic linkages to become shallower over the last two decades.

Adopting a GVC perspective, the most recent contributions within this literature highlight the mediating role played by the organisational structure in the global mining equipment industry, and the quality of interactions among lead mining companies and their immediate suppliers in limiting or enhancing upgrading opportunities for local suppliers (Pietrobelli et al., 2018). Moreover, discussing the case study evidence, they are also starting to acknowledge the importance for local suppliers in emerging countries of developing what they refer to as the "capabilities complementary to production and innovation" (Pietrobelli et al., 2018; Stubrin, 2017) in order to be able to exploit their core scientific and technological know-how, and ultimately capture value from upgrading efforts.

However, so far, these two aspects have not been explored in depth. First, the studies reviewed above primarily build on early contributions to the GVC literature (Gereffi, 1999; Gereffi et al., 2005) that do not devote sufficient attention to the sources of firm-level agency of non-lead companies and its relevance in altering the organisational structures within global

[111] Examples include Stubrin (2017) in Chile, Molina (2018) in Peru, Figueiredo and Piana (2016, 2018) in Brazil, and Kaplan (2012) and Morris et al. (2012) in South Africa.

industries. Specifically, little effort has been made to understand how a small group of large, powerful, incumbent and emerging suppliers has played an increasingly influential role in the functioning of mining global value chains (MGVCs) over the past two decades. Their emergence and consolidation, indeed, have important implications for value chain polarity, horizontal competition dynamics, upgrading and value capture opportunities for local equipment producers from developing countries. Second, in the reviewed studies, the role of the capabilities complementary to the core technological ones needed by local suppliers in developing countries for entering into more fruitful bargaining processes with chain leaders is mainly treated as a research challenge deserving further consideration in the future (Stubrin, 2017; Molina, 2018; Pietrobelli et al., 2018). So far, these contributions have principally focused on how certain emerging countries' suppliers have achieved a relatively advanced level of technical mastery in terms of product conception, design and development, without, however, conceptualising the broader set of GVC-specific capabilities needed to successfully commercialise the results of their upgrading efforts and profit from them.

These studies mainly build on the body of literature on technological capabilities (Lall, 1987 and 1992; Bell and Pavitt, 1995), but they do not tailor this analytical tool to the specific industry being studied. While providing very important insights, the general classificatory principles proposed by Lall (1992) need to be adapted and extended to take into account the broader set of capabilities necessary to meet the requirements for participating, upgrading and maximising value capture in specific sectoral GVCs as they have evolved in the 21st century (Staritz et al., 2017; Andreoni, 2018; Whitfield et al., 2020). And, in fact, in addition to the technical efficiency of the equipment and the costs, quality and reliability of its delivery, other factors have become particularly important in the context of a high-cost capital goods value chain like the mining machinery one. These include, among other things, organisational competences to reduce lead times and respond rapidly to changing market conditions, but also a set of complementary, non-production capabilities and resources to enhance the commercialisation of, and appropriability from, innovative proprietary equipment,[112] and to effectively manage input sourcing, inventory, distribution activities, maintenance, repair and financing operations (Davies, 2004; Brady et al., 2005; Kiamehr, 2017; Bamber et al., 2016).

The following section examines in more detail these two aspects, in an attempt to sketch an 'augmented' GVC framework to better interpret the empirical evidence from case studies

[112] Being able to commercialise a certain technology is about scaling it up (Andreoni and Tregenna, 2020), while appropriability from commercialisation refers to the ability to design products that can be produced at effective scale (Teece, 2018).

focusing on the development trajectories of suppliers from emerging economies. In doing so, it reviews a number of research areas within and beyond the GVC literature and argues that, if combined, they can refine our understanding of the sources of supplier firm agency (i.e., the strategies and process of building capabilities) and its role in shaping the governance, polarity and competition dynamics within the chain, as well as the upgrading and value capture prospects of different supplier firms.

5.3 On the supplier firm agency in GVCs: reconsidering governance and value capture dynamics

5.3.1 Value chain polarity, supplier firm power and new competition dynamics in global industries

Within the GVC framework, *governance structures* refer to the inter-firm arrangements and institutional mechanisms that make possible the coordination of internationally dispersed activities in the chain. They obviously have to do with the exercise of control over the chain and have also crucial implications for upgrading and the value distribution[113] dynamics along it (Humprey and Schmitz, 2002). Traditional GVC approaches have focused typically on analysing unipolar value chains – be they buyer- or producer-driven (Gereffi, 1994), or along the hierarchy-market spectrum (Gereffi et al., 2005) – where the lead firm plays a key role in shaping the chain organisation.

However, little or no consideration has been given to the ways in which other influential actors, particularly large and powerful first-tier suppliers, might alter the prevailing governance pattern over time. An important exception can be found in Milberg and Winkler (2013), who stress how the endogenous asymmetry of the market structure characterising GVCs might take a variety of different forms, each implying a specific distribution of power and value added along the chain's nodes. In particular, the illustrative cases of market structures characterised by strong first-tier suppliers and middlemen (Milberg and Winkler, p. 125) implicitly suggest the relevance of other powerful firm-actors aside the lead company.

Building on previous research on twin-driven commodity chains (Fold, 2002; Islam, 2009), in an influential paper, Ponte and Sturgeon (2014) have taken a significant step forward in expanding this direction further to suggest analysing governance across a unipolar to

[113] The expression 'value distribution' here refers to the fact that different activities performed along the value chain have a different scope for value creation, but it also points to the differences between who creates such value and those who are in a position to capture and appropriate it.

multipolar continuum. A key idea behind their contribution is that multipolar value chains are shaped by the explicit strategic actions of powerful and co-existing firm- and non-firm actors.[114] More specifically, in the case of other firm-actors, when a first-tier supplier is a transnational company with a global footprint just like the lead firm (Sturgeon and Lester, 2004; Sturgeon and Van Biesebroeck, 2011; Whittaker et al., 2010), the emerging bilateral monopoly might result in unspecified structures of governance.

This study focuses on two key and interrelated reorganisation trajectories taking place at the global level on the supplier side in a number of industries: first, the increasing role played by a handful of powerful multinational incumbent suppliers; and, second, the emergence on the global scene of a number of increasingly competitive Chinese suppliers. It is argued that these supply-side dynamics have been particularly relevant, albeit to varying degrees, in shaping the chain polarity and the competition dynamics in the global mining equipment industry.

The growing relevance of a small group of large TFSs from advanced countries has been documented across different medium- to high-technology manufacturing industries, such as electronics, automotive, oilfield equipment and services (Raj-Reichert, 2019a and 2019b; Sako and Zylberberg, 2019; Tordo et al., 2011; Perrons, 2014; Lima de Oliveira, 2016). In fact, the concentration and consolidation dynamics characterising many global industries after the mid-1980s took place not only among lead firms, but were propagated along the entire value chain via a 'cascade effect', which exerted pressure towards consolidation and growth on suppliers in all tiers (Nolan et al., 2008; Gereffi, 2014). As a result, these TFSs have been able to upgrade and capture value along several GVCs through a number of strategic initiatives allowing them to access and control specialised complementary resources and capabilities[115] for the successful commercialisation and appropriability of the results of innovation and upgrading (Raj-Reichert, 2019a; Sako and Zylberberg, 2019).

Alongside these value chain restructuring dynamics governed by leading multinationals from advanced countries, case evidence of powerful first-tier suppliers from emerging economies, and in particularly from China, is clearly emerging (Williamson and Zeng, 2009). While large

[114] The plurality of players to which Ponte and Sturgeon (2014) refer also involves non-firm actors, such as standard-setting institutions, certification bodies, non-governmental organisations (NGOs), social movements and labour unions (Ponte, 2014; Mayer and Philips, 2017; Alford and Phillips, 2018). However, the main focus here is primarily on how first-tier suppliers navigate the constraints imposed by the lead firms and other non-firm actors and institutions, and, eventually, reshape the chain polarity and the rewards offered by participation in GVCs.

[115] In the present work resources and capabilities refer, in a Penrosian way, to the bundle of tangible and intangible assets available to an organisation and to the capacity to deploy a combination of resources through collective organisational routines to achieve specific objectives, respectively (Penrose, 1959).

Chinese OEMs still lag behind TFSs in terms of brand reputation and capabilities in many global industries (Brandt and Thun, 2016; Bruche and Hong, 2016; Safdar and Van Gevelt, 2020), they are controlling and reshaping domestic, regional and global value chains in a number of sectors, such as apparel (Azmeh and Nadvi, 2014; Morris and Staritz, 2014; Morris et al., 2016), electronics (Sturgeon and Kwakami, 2011), renewable energy (Lema et al., 2013; Zhang and Gallagher, 2016; Baker and Sovacool, 2017), construction equipment (Brandt and Thun, 2016; Bruche and Hong, 2016), and natural resources industries and related fields (Fessehaie, 2012a; Fessehaie and Morris, 2013; Bamber et al., 2016). Taking advantage of the huge segmented domestic market, and highly supportive and targeted government policies, these new actors have gradually upgraded along multiple value chains (Lee, 2019), performing a variety of different functions according to the specific geographical scale of production networks, either global, regional or domestic (Yang, 2013).

The analysis of how these incumbent and emerging first-tier suppliers are modifying their power position in global industries requires an understanding of the different forms of power they can exercise along GVCs. To this purpose, the most recent and consolidated typology of power in the GVC literature to date (Dallas et al., 2019; Ponte et al., 2019) is taken as a conceptual framework here. According to that framework, control and influence in GVCs can be exercised or transmitted directly or diffusely (i.e., more or less intentionally) in collectives, through institutional and constitutive forms of power, or in dyads, through bargaining and demonstrative powers. These latter two forms of power correspond to the ones primarily exerted by large incumbent TFSs and emerging Chinese manufacturers.

These companies, indeed, are increasingly able to exercise competence-driven dyadic and direct bargaining power over their lead customers, shifting from more asymmetric toward increasingly symmetric types of vertical relations along the hierarchy-market spectrum of governance types (Gereffi et al., 2005). Moreover, the emerging multipolarity characterising many global industries also has implications for the relationships of these powerful companies with other first-tier suppliers and it suggests the need to look beyond the power dynamics between lead firms and suppliers (i.e., chain polarity) to examine those between competing suppliers (i.e., horizontal competition). Large incumbent TFSs (Raj-Reichert, 2019b; Sako and Zylberberg, 2019) and emerging powerful Chinese OEMs (Intarakumnerd and Fujita, 2009), indeed, exhibit forms of competence-driven dyadic and diffuse demonstrative power over other competing first-tier suppliers, indirectly raising the bar of operating multiple chains for them by establishing higher requirements for value creation and value capture through different strategic initiatives. The appearance on the global scene of these new actors might change the characteristics of markets and the critical factors for success for all other competing first-tier suppliers (Sturgeon and Linden, 2011).

The rise of TFSs and the related trends toward multipolar governance structures have profound implications, especially for suppliers in developing economies trying to enter, upgrade and build stronger competitive positions along GVCs. Particularly in emerging countries that have liberalised their economic systems over the past decades, oligopolies have rapidly been established in different sectors, not only by global leading multinationals, but also by their large TFSs (Nolan et al., 2008). As a result, on the one hand, suppliers from developing countries often find themselves locked in far more asymmetrical vertical relations with their end-clients than their transnational first-tier competitors. On the other hand, they face an intensified competitive pressure from these large TFSs which, over time, have gained a dominant position within the chain as high-value integrated solutions providers.

The increased competition exerted by large TFSs might force adaptation among other suppliers to meet increasingly advanced and stringent requirements, but it might also cause stagnation, downgrading and exclusion from more demanding GVCs (Barnes and Kaplinsky, 2000; Bair and Gereffi, 2001; Nadvi and Halder, 2005). Since TFSs are increasingly evolving towards high-value integrated proprietary solutions providers, building strategic partnerships with them, while maintaining their independence as OEMs, is less of an option nowadays for developing countries' competitors.

The upgrading of large Chinese companies in many global industries is also exerting substantial competitive pressure on other first-tier suppliers, from both advanced and developing countries. Specifically, the global rise of Chinese players, and more generally of Chinese exports[116] in many MHT sectors, is increasing the challenges faced by many firms from other emerging economies with similar capabilities (Kaplinsky and Messner, 2008; Horner, 2016; Bamber et al., 2016; see also Chapter 4 in this thesis). As a result, it might force them to adjust to the new competitive landscape through a mix of strategic initiatives, including technology partnerships, adaptive downgrading and specialisation in complementary tasks (Intarakumnerd and Fujita, 2009; Blažek, 2016).

[116] Chinese exports also include goods from advanced countries' multinational first-tier suppliers produced or assembled in China and then shipped to other destinations.

5.3.2 Supplier firm capabilities, upgrading and value capture in GVCs

The concept of *upgrading* represents the second key notion of the GVC framework and is defined as the process through which economic actors move from performing lower value added to relatively higher value-added activities along the chain. Building on the seminal contribution by Gereffi (1999), Kaplinsky and Morris (2001) and Humphrey and Schmitz (2002) established the now widely accepted four-fold categorisation of upgrading trajectories – namely process, products, functional and chain (or inter-sectoral).

According to the original GVC framework one of the key sources of upgrading and change in the governance structure is the increase in a supplier's capabilities (Gereffi, 1999; Gereffi et al., 2005). While early empirical GVC studies do not address the details of their nature and the dynamics of their accumulation (Kaplinsky and Fitter, 2004), a more recent stream of the literature explicitly identifies a strategic relationship between upgrading, interpreted as a form of innovation, and latecomer firm- and country-specific technological capabilities (Morrison et al., 2008; Sato and Fujita, 2009; Fujita, 2011; Pietrobelli and Rabellotti, 2011).

These capabilities are defined as the technical, organisational and institutional competences needed by developing countries' firms to utilise efficiently equipment and information, and to generate and manage any process of technological change. According to Lall's taxonomy (Lall, 1992), technological capabilities are categorised by technical functions (i.e., investment, production, linkages) and degree of complexity (i.e., basic, intermediate, advanced).[117] Following such classification, studies within the GVC literature argue that building and deepening investment, production and linkages capabilities are indeed crucial for different forms of upgrading along GVCs (Morrison et al., 2008; Pietrobelli and Rabellotti, 2011).

As already mentioned, this framework has been applied extensively to the case of natural resources industries and related backward sectors in developing countries. However, these contributions have mainly focused on how a number of firms in developing countries have

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[117] Investment capabilities are the skills necessary for generating technical change and managing its implementation during large investment projects: these include the capabilities needed to assess the feasibility and profitability of projects and to determine their specifications, including the technology required, the selection of the best sources, the negotiations concerning its procurement, and the recruitment and training of the skilled personnel needed. Production capabilities are the skills necessary for the efficient operation of a plant and its improvement over time. Process, product and industrial engineering capabilities are key aspects of this subclass. Among the production operations requiring adequate skills are the following: absorption of technology, its adaptation and upgrading, quality and inventory control, productivity's monitoring, co-ordination of production tasks and units, and process and product innovations related to basic research. Linkage capabilities are the skills needed to share information, competences and technology with own suppliers, subcontractors, consultants, technology institutions and other external organisations (Lall, 1992; Morrison et al., 2008).

achieved a relatively advanced level of technical mastery in terms of product conception, design and development, using the traditional technological capabilities framework (Lall, 1987; Lall, 1992; Bell and Pavitt, 1995). Unlike recent detailed micro-level sectoral studies (Staritz et al., 2017; Whitfield et al., 2020; Figueiredo et al., 2020), they fail to adapt and expand this generic analytical tool to the specific global industry being studied, and to conceptualise the broader set of sectoral GVC-specific capabilities required by suppliers to successfully commercialise the results of their innovation efforts and thus maximise value capture from their upgrading paths.

In fact, with few exceptions (Kaplinsky, 2000; Schrank, 2004; Mahutga, 2014; Milberg and Winkler, 2013), the GVC literature is generally silent on the circumstances under which value creation leads to value capture for the supplier undertaking upgrading. Moreover, while discussing regional and local value capture, neither GPN scholars have fully addressed this limitation at the firm-level (Murphy and Schindler, 2011; Coe and Yeung, 2015). Finally, both frameworks typically fail to distinguish those capabilities and resources necessary to enter and survive in certain sectoral value chains from those needed to capture value and/or compete at the global technological frontier.

Recent contributions at the intersection between GVC and international business literature underline that the core technological and production-related capabilities are obviously necessary, but alone inadequate, for entering into more fruitful bargaining processes with chain leaders and, ultimately, for capturing a greater share of the aggregate value (Staritz et al., 2017; Sako and Zylberberg, 2019; Raj-Reichert, 2019b; Whitfield et al., 2020).

Sako and Zylberberg (2019) improve the predictive and prescriptive power of GVC theory by drawing on the core constructs of the dynamic capability framework (Teece, 1986; Teece et al., 1997; Teece, 2007; Teece, 2014). They argue that suppliers might fail to capture the value they create by investing in upgrading if the accumulation of advanced core technical competences is not backed up with specialised and co-specialised complementary resources (e.g., related technologies, competitive manufacturing systems, distribution channels, after-sales support networks), and with the capabilities needed to organise and manage them. In other words, depending on the specific sectoral GVC, securing and deepening a set of resources and capabilities complementary to the core technological ones is an essential requirement for suppliers to successfully commercialise the results of their innovation; to profit from it, to scale up and consolidate in international markets and, ultimately, to exert increased bargaining and demonstrative power on lead buyers and other suppliers, respectively.

Along similar lines, Whitfield et al. (2020) expand and adapt Lall's categories of technological capabilities to take into account a broader set of capabilities necessary to meet the requirements to enter, upgrade and capture value in specific sectoral GVCs, in addition to the technical efficiency of the product and the costs, quality and reliability of its delivery. These include the organisational competences to reduce lead times and respond rapidly to changing market conditions, but also a set of complementary non-production capabilities and resources to enhance the commercialisation of products and to effectively manage input sourcing, customer relations, inventory, logistics, financing and compliance with labour, safety and environmental standards (Staritz et al., 2017). To this purpose, they generate detailed sectoral GVC-specific capabilities matrices, combining their refined versions of Lall's classificatory principles with upgrading typologies.

Building on such recent advances at the intersection between the international business, technological capabilities and GVC literature (Staritz et al., 2017; Sako and Zylberberg, 2019; Whitfield et al., 2020), this chapter argues that an extended bundle of sectoral GVC-specific capabilities is needed by firms to capture value from their upgrading efforts. In doing so, I underline the relevance of the interaction between the core technological capabilities (i.e., technical mastery in terms of product conception, design and development) with a broader set of sector-specific complementary resources and capabilities in shaping the ability of firms to build, maintain and renew international competitiveness in the context of a globalised and increasingly competitive environment.

In this respect, building up and strengthening these complementary capabilities is particularly important for those firms in certain emerging economies which have already built an advanced base of core technical knowledge and expertise to enter and survive in global industries, and are in a transition process towards competing at the global technological frontier. Table 5.1 reports a general capability matrix for analysing upgrading patterns in GVCs, which has been generated by building on insights from earlier contributions such as Lall (1992), Bell and Pavitt (1995), Teece (1986), Teece et al. (1997) and more recent ones like Andreoni (2014 and 2018),[118] Sako and Zylberberg (2019), and Whitfield et al. (2020).

[118] Specifically, the concepts of industrial ecosystems, sectoral value chains and capability domains introduced in Andreoni (2018) have been particularly useful to structure the present analytical framework.

Table 5.1. A general capability matrix for analysing upgrading and value capture patterns in GVCs.

	Categories of capabilities				
Functions in GVC[a]	Investment	Product design	Process and production organisation	End-market development and services	Linkages
Function 1 (*basic*)					
Function 2 (*intermediate*)					
Function 3 (*advanced*)					

Note: [a] The elaboration of basic, intermediate and advanced functional specialisation can include as many rows as needed to capture real-world patterns of upgrading and value capture within specific sectoral GVCs.
Source: Own elaboration based on previous literature.

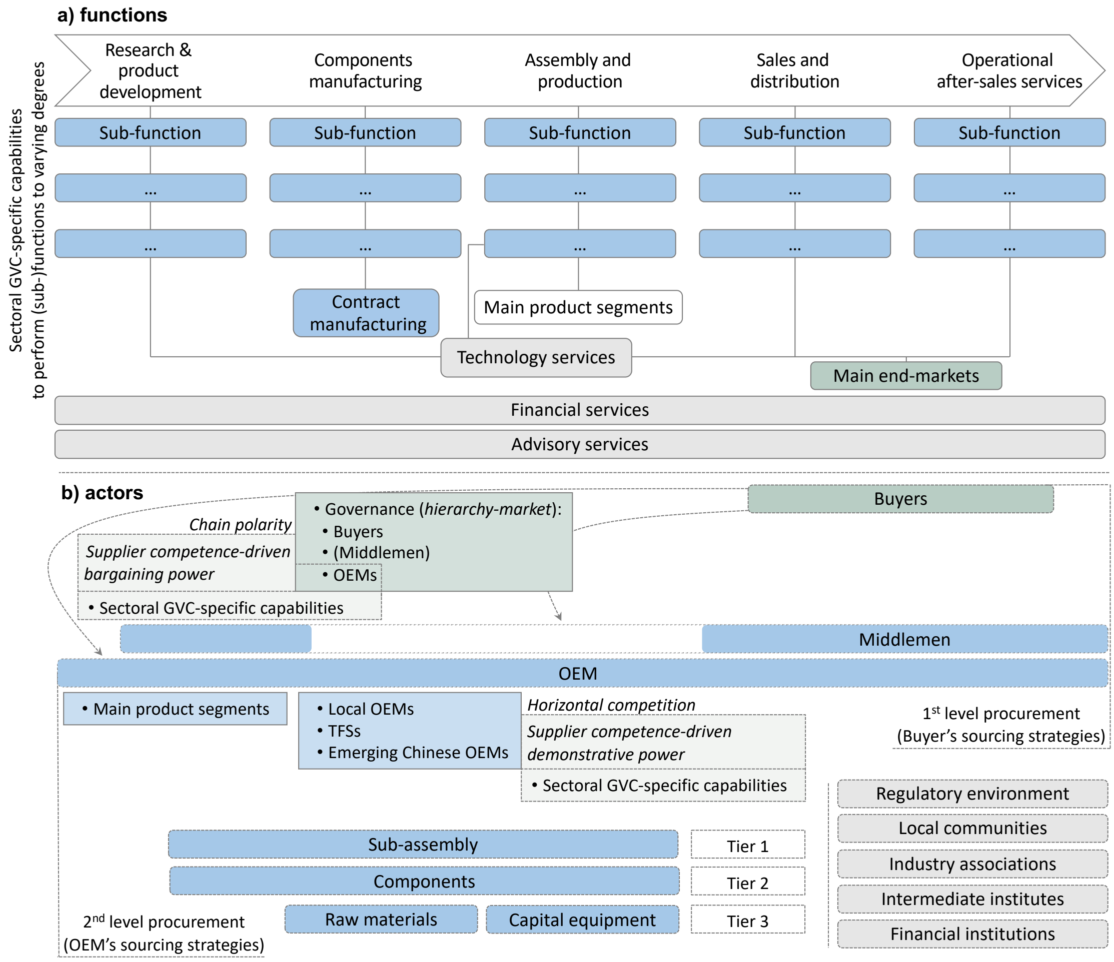
The vertical axis corresponds to the functional specialisation stages within a generic GVC, from those requiring the mastery of certain basic skills to those involving the strengthening of increasingly complex capabilities. As for the horizontal axis, the traditional investment, production and linkages categories of technological capabilities (Lall, 1992; Bell and Pavitt; 1995) have been adapted to better reflect issues related to upgrading trajectories in GVCs. First, I differentiate between *product design* capabilities and *process and production organisation* capabilities. Second, following Whitfield et al. (2020) and given the importance of the relationships with lead end-clients in GVCs, I create a separate capability category named *end-market development and services* in addition to the linkages category. This category refers to capabilities and complementary resources to perform customer-centric activities such as logistics, operational after-sales services and vendor financing. Finally, the matrix also underlines the importance of the *investment* capabilities affecting scale, product portfolio, technology, skills and equipment selected, as well as the *linkages* capabilities required to build stable relations with suppliers, industry experts, and public and private sector institutions.

On this last point in particular, one can distinguish between internal and firm-specific, as well as external, country- and ecosystem-specific, capabilities, which are interrelated and often strongly interdependent. The latter, in particular, refer to the support system provided to companies by their home country's public institutions and private actors. In particular, government intervention in terms of incentives regimes (e.g., trade policies and domestic industrial policies), factors markets (e.g., availability of skills, raw materials and components, and industrial finance) and institutions that support industrial development (e.g., education and training, intermediate institutes, laboratories, testing facilities and standards institutions) shape the acquisition, nature and development of the strategic capabilities of nations and ecosystems, and this in turn affects the capability accumulation process at the firm level (Freeman, 1987; Lall, 1992; Malerba, 2004; Malerba and Mani, 2009; Andreoni, 2018).

On one side, Table 5.1 considers the shift of firms to upward nodes in GVCs (i.e., functional upgrading), represented by top-down movements along the rows. On the other side, it also takes into account the possibility that firms deepen certain capabilities while remaining in the same node of GVCs (e.g., product, process, end-market, and supply chain upgrading), represented by movements along specific columns (Staritz et al., 2017). Finally, inter-sectoral upgrading – i.e., the strategic move of firms applying the capabilities acquired in a certain specific sectoral GVC to enter into another sectoral GVC – is represented by 'jumps' from one sectoral GVC-specific capability matrix to another. Importantly, this framework also allows for a differentiation between upgrading paths and value capture within different context and sectoral GVCs: in fact, different configurations of firms' capabilities and upgrading paths might lead to extremely different value capture trajectories. So, as an example, it might be the case that a firm specialising in the first functional step of a specific sectoral GVC, with basic product and process capabilities but with certain advanced key investment, linkages or end-market capabilities, is able to capture more value than a company performing relatively more advanced functions, but characterised by intermediate capabilities in those areas (Whitfield et al., 2020).

In sum, the framework outlined in Sections 5.3.1 and 5.3.2 aims to advance our understanding of supplier firm agency by focusing on the strategies and processes of building the capabilities of both foreign and local firms in their efforts to upgrade and capture value along the value chain. On one side, by reviewing recent advances in the changing organisational structures characterising global industries, I have identified the sources of foreign supplier firm agency (i.e., strategies and process of building certain key capabilities) and its effects on the overall structure of the value chain, including on lead companies and on competing suppliers (see Section 5.3.1). On the other side, by building on recent advances at the intersection between the international business, technological capabilities and GVC literature, I have argued the importance of adopting novel conceptual tools (i.e., sectoral GVC-specific capability matrices) for analysing real-world upgrading and value capture patterns along these chains. Specifically, these matrices should allow me to identify those capabilities complementary to the core technological ones necessary to meet the requirements to enter, upgrade and capture value in specific sectoral GVCs (see Section 5.3.2). This GVC framework, augmented by such theoretical considerations, is represented in Figure 5.1 below. It provides the researcher with additional guidelines to empirically analyse, on the one hand, the reasons behind the success of certain large and powerful foreign suppliers, and, on the other hand, the sources of the constrained agency of their local competitors from developing countries, as well as their limited room for manoeuvre to capture value from investments in upgrading.

Figure 5.1. An augmented framework for analysing specific sectoral GVCs.



Source: Own elaboration based on the critical review of the literature in Sections 5.3.1 and 5.3.2.

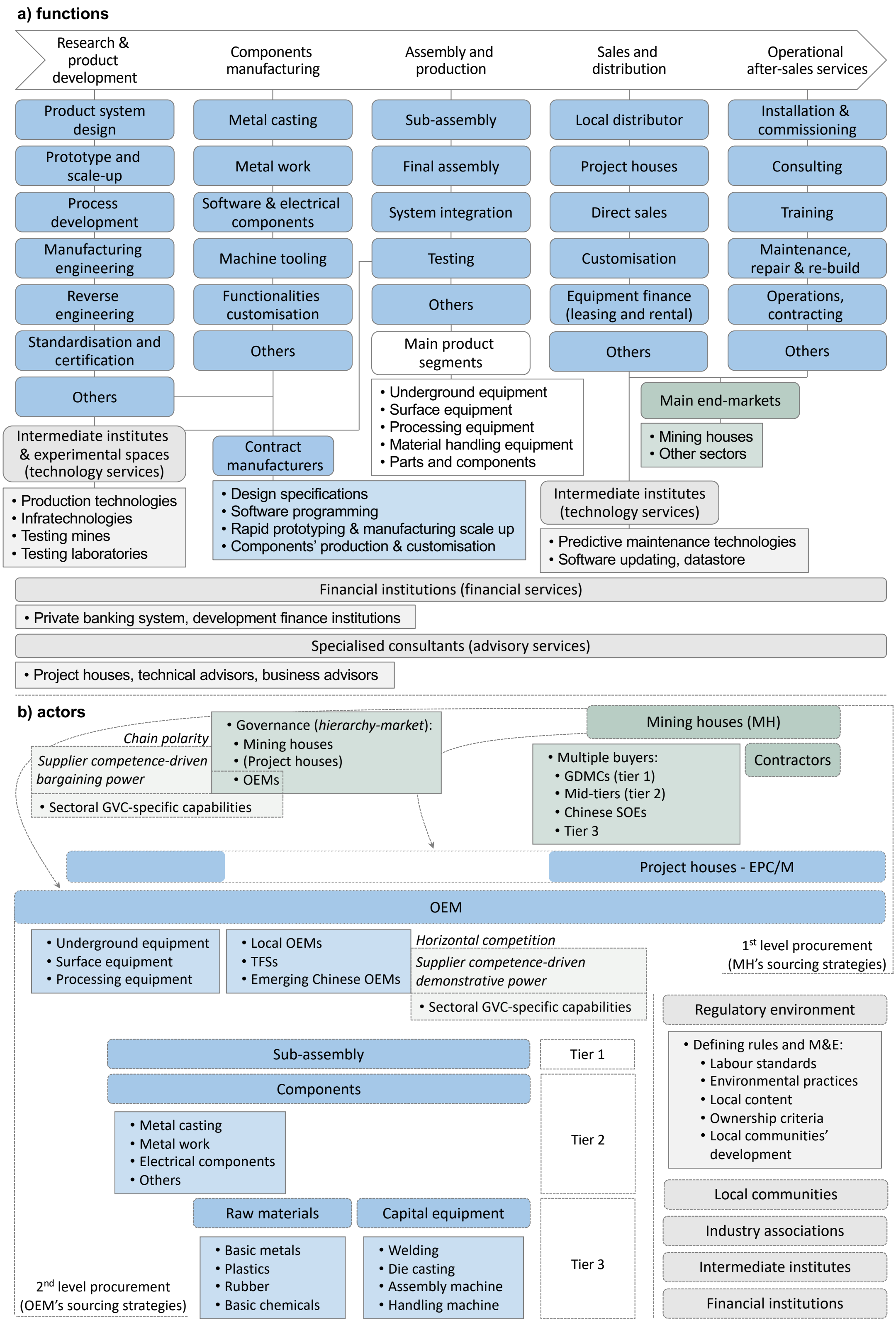
5.3.3 The mining equipment GVC: structure, value-adding stages and suppliers' capabilities

In what follows I operationalise this framework in the global mining equipment industry. First, the structure of the value chain is briefly sketched. Then, the key value-adding activities are discussed in more detail, focusing on mining equipment producers. Finally, the main value capture opportunities along the value stream are identified, together with a broad and detailed set of GVC-specific capabilities to successfully seize them.

5.3.3.1 The structure of the mining equipment industry

As shown in Figure 5.2, the mining equipment value chain encompasses a large number of functions and sub-functions, ranging from research and product development to operational after-sales services. Different actors are involved along the stages of the value chain, according to their respective tasks.

Figure 5.2. The mining equipment value chain: functions (a) and actors (b).



Source: Own elaboration based on information gathered through interviews with industry's representative.

In what follows, the key firm and non-firm actors, and their respective functions along the chain, are briefly introduced.

Mining equipment end-markets

Mine owners and contractors operate the mines, and are the main end-markets for mining equipment producers. From previous studies (Morris et al., 2012; Fessehaie, 2012a and 2012b; BGR, 2016) and own interviews it has emerged that the form and origin of ownership, the size and the geographical scope of operations are among the key factors shaping the governance configurations and procurement strategies of lead mining companies (i.e., what I refer to as 1st level procurement in Figure 5.2). These features constitute the sources of the heterogeneity observed in the sector on the demand side, that, in turn, give rise to the emergence of multiple value chains and as many end-markets for the suppliers of the equipment.[119] In Southern Africa, in particular, four different groups of lead buyers can be identified.

1. A handful of global diversified mining companies (GDMCs) with sales revenues above USD 500 million (BGR, 2016). These well-capitalised traditional investors[120] own, manage and operate numerous, diversified and global mining operations. They constitute the most coveted high-end and large-volume market for world class and premium mining equipment producers.
2. Mid-tier, privately owned companies, with a traditional (often South African) majority ownership and sales revenues between USD 50 and USD 500 million (BGR, 2016). These own, manage and operate a limited number of mines, usually located in one or two countries, largely focusing on certain specific commodities and on the domestic market. They represent a high-end market for premium mining equipment that, however, does not provide suppliers with a global large volume demand.
3. Large mining houses with state-owned Chinese majority ownership. Chinese investors in sub-Saharan Africa have been found to be distinctive with respect to traditional mining companies in terms of budget constraints, risk appetite, long-term orientation,

[119] Other key lead firm's characteristics (e.g., diversification of the commodity portfolio, financial capacity, functional specialisation and local embeddedness) are also functions of its form and origin of ownership, and the size and geographical scope of its operations, and contribute to the definition of the procurement strategies and the governance configurations of lead mining companies.

[120] 'Traditional investors or buyers' are defined here as those privately owned mining companies with a North American, European, Australian or South African majority ownership. In the literature (Fessehaie, 2012a; Morris et al., 2012), these are distinguished from 'emerging investors or buyers', that mainly indicate lead mining houses with Indian, and especially Chinese, majority ownership. The relevance of such distinctions in practice, with respect to procurement strategies and supply chain governance patterns, has been confirmed during own interviews with industry representatives.

procurement strategies and governance structures. Other empirical evidence has underlined the appropriateness of differentiating between traditional and Chinese investors in practice (Fessehaie, 2012a; Morris et al., 2012).[121] This is not generally considered a high-end market by equipment producers. However, recently, for certain core technologies, these companies have started to rely on premium mining equipment producers.

4. Smaller, tier-3, formal mining companies with more limited access to funding (also referred to as the *junior* or *emerging miners*) focusing on one or two key commodities (MCSA, 2019). Many of these specialise in exploration activities without engaging in the production process, while others manage and operate smaller-scale operations characterised by relatively short time horizons, primarily in the domestic and regional markets.[122] They mainly constitute a price-conscious and CapEx-sensitive mid-segment market for mining equipment producers.[123]

Project houses

These engineering middlemen can be contracted by the end-client to manage the planning, design and development phases of a mine, and they are particularly active in the mineral processing market. They can act as EPCM (Engineering, Procurement and Construction Management) companies or as EPC (Engineering, Procurement and Construction) companies, and their responsibilities in terms of equipment procurement vary according to the specific contracting model in place with the end-client.[124] These engineering contractors play a central role in specifying and selecting equipment suppliers, either as decision-influencers or decision-

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[121] Privately owned Chinese investors have not been included in this study because of the lack of primary and secondary information on them. Moreover, while overseas foreign investments undertaken by private Chinese firms represent an increasingly important phenomenon in many global industries, in the natural resource sector the dominance of SOEs has been particularly significant in the past two decades (Gelb, 2010; OECD, 2008).

[122] The small, artisanal and often informal companies operating only one or two mining assets nationally are not included in this study. These miners do not constitute an end-market for the type of suppliers this study is interested in. Their operations are rather low-tech and highly labour-intensive, and do not make extensive use of mechanised equipment (Hilson, 2009).

[123] There is no consensus around the definition of emerging and junior miners in Southern Africa. A recent report developed by the Mineral Council of South Africa (MCSA, 2019, p.16) defines them as companies with less than 500 employees and revenues in the past tax year between 50 and 500 million Rand.

[124] Under EPCM contracts, the project house acts as an agent for the end-client, carrying out engineering, designing and procurement specifications on behalf of the mining house. The mining house is directly responsible of awarding and signing contracts with selected suppliers, taking into account the EPCM's recommendations. The project house is generally paid on a cost-plus basis and it is not responsible for cost overruns and project delays. Under EPC contracts, the procurement phase is directly managed by the project house, which awards and manages all contracts with selected suppliers. The EPC is generally paid on fixed price basis, and it bears the risk of cost overruns and project delays. The EPC contracts flourished during the commodity boom, when the market's demand for risk shifting from mining companies to engineering contractors was extremely high. Figure C.1.1 in Appendix C provides a schematic diagram with the key three alternative contracting models in mining projects.

makers. In certain circumstances, under specific project delivery models and given the capabilities of the end-client, they might produce changes in the chain polarity, raising or lowering barriers of entry for local suppliers in emerging countries.[125]

Mining equipment manufacturers

Mining equipment manufacturers, which constitute the main focus of the present work, perform the bulk of the functions summarised in Figure 5.2. These firms design, manufacture and provide operational after-sales support for the equipment. They might outsource different stages of R&D, manufacturing, distribution and after-sales service to other actors, or perform some of these tasks in close collaboration with end-clients and engineering contractors.

OEM supply chains

Mining equipment companies can outsource sub-assembly and manufacturing components, and sub-system fabrication stages to tier-1 and tier-2 suppliers. Tier-3 suppliers mainly provide raw materials (e.g., steel, non-ferrous metals and alloys, basic plastics and chemicals) and capital equipment used in the fabrication of components (i.e., all these stages form what I refer to as 2^{nd} level procurement in Figure 5.2).

Other stakeholders

This group includes governments and public sector institutions, local communities, industry associations, specialised intermediate technology institutes and financial institutions. The regulatory framework, in particular, defines the rules and the standards under which exploration, extraction and production of natural resources take place. Regulatory authorities are responsible for granting mining concessions and monitoring how mining companies deal with issues of local content, ownership requirements, environmental impact, human risk, safety and labour standards.

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[125] Some interviews have stressed that the origin of ownership (e.g., traditional or Chinese in this case), the size and the degree of specialisation (e.g., specialised in certain commodities or diversified) can exert some influence in their selection by lead mining houses as well as in their sourcing strategies and preferences. However, this source of heterogeneity is not fully investigated in the present study because of the lack of enough empirical evidence and it is left for future research.

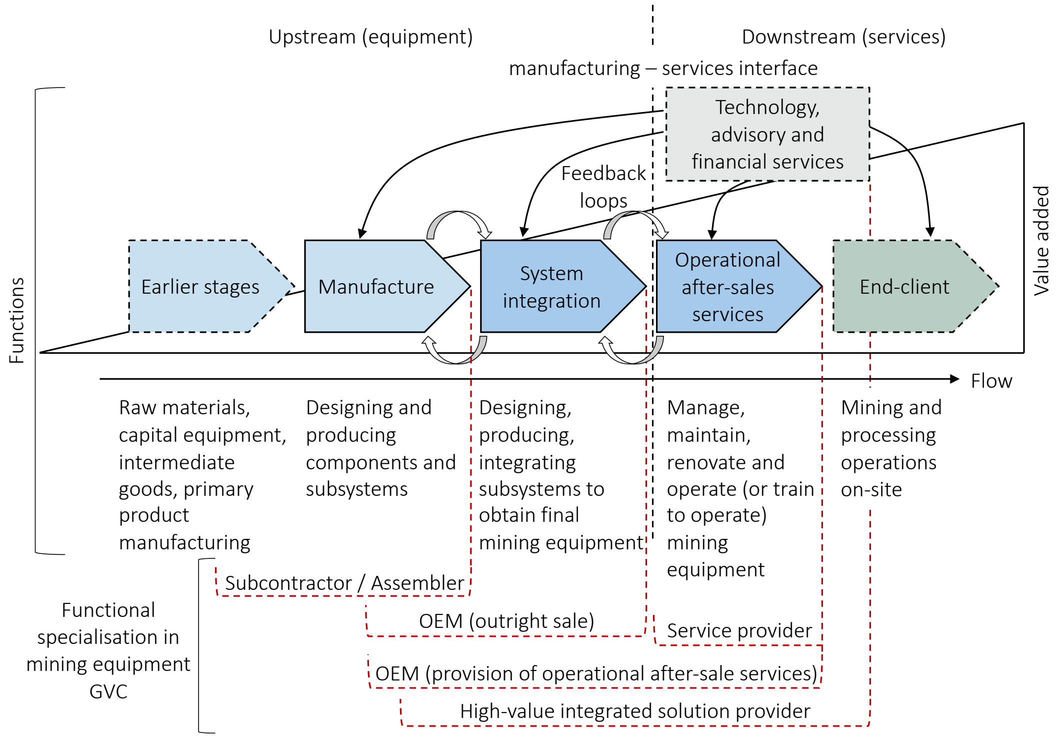
5.3.3.2 Value-adding stages and functional specialisation along the mining equipment value chain

Mining equipment manufacturers are the first-tier suppliers of mining companies and project houses. They can specialise in one or more product segment, from underground and surface mining machines to mineral processing and material handling equipment.[126] To account for the different activities performed by mining equipment producers, Figure 5.3 summarises information from the functions panel in Figure 5.2, identifying the three key steps in the value stream of a typical producer operating in this industry (i.e., manufacturing, system integration, operational after-sales services). It also identifies the main five stylised functional upgrading stages in which these suppliers may specialise (i.e., subcontractor, OEM selling the equipment outright, service provider, OEM providing after-sales services and high-value integrated solution provider).

Each of these functional phases in the value stream is progressively closer to the end-client. This ensures greater levels of value capture, but means there are different business problems to be faced, often requiring different, increasingly diverse and widespread capabilities to be performed. The information reported in Figure 5.3 is mainly based on extensive primary research and insights from the academic literature on high technology and high value capital goods, also known as 'complex product systems' (CoPS), and on KIMS.[127] However, it is important to underline that Figure 5.3 is just a stylised linear representation of a process that, in practice, may evolve along very heterogenous trajectories. This scheme should be regarded as an interpretative tool mainly intended to facilitate the analysis of the empirical findings.

[126] See Section C.1.2 in Appendix C for additional details on product segments in mining equipment.
[127] In particular, on CoPS, see Davies and Brady (2000), Davies (2004), Hobday et al. (2005) and Brady et al. (2005). On CoPS in emerging countries, see Hansen and Ockwell (2014) and Kiamehr (2017). For the mining equipment sector see Bamber et al. (2016) and the literature on KIMS discussed in Section 5.2. In terms of the present research, this includes over nine months of fieldwork in South Africa (see Section 5.4, discussing methods, data collection and analysis).

Figure 5.3. Value stream and functional specialisation in mining equipment manufacturing and servicing.



Notes: 'Value added' on the right y-axis refers to the cumulative process of value addition from raw materials to the final product system. It is not intended to give a precise indication of the stages in which the bulk of the value is actually produced – that, in this sector, generally concentrates within the manufacturing and system integration stages.
Source: Own elaboration based on information gathered through interviews with industry representatives.

Manufacture. During this stage raw materials and sub-assemblies are transformed into physical components and sub-systems. These need to be manufactured to meet the overall machine design. Subcontractors mainly specialise in the manufacturing stage of production, performing a portion of assembly or finishing activities on behalf of the first-tier supplier.

Systems integration. During the second stage, value is added through the design and integration of physical components and sub-systems that have to function together as a whole in the final equipment. OEMs and solution providers can outsource sub-assembly and manufacturing components fabrication stages to external suppliers or source them from in-house product divisions. Regardless the specific organisational structure in place, OEMs and solution providers are responsible for managing a number of internal production departments and external contractors, which are in charge of manufacturing the sub-systems comprising the final equipment.

Operational after-sales services. During the last stage, value is added through maintaining, repairing and operating (or training end-customers on how to operate) the final equipment. Under the first typology of original mining equipment manufacturing introduced in Figure 5.3, OEMs follow a fail-and-fix approach, selling the equipment outright and only providing service when a machine breaks down. However, during the past two decades, the nature of after-sales support services has significantly evolved in the sector, in conjunction with the abandonment of traditional backward vertical integration strategies by GDMCs, which started to outsource peripheral activities previously handled in-house to their suppliers (Urzua, 2012). As a result, a number of OEMs in this sector have expanded the scope of their product offering to include services in order to capture the life-cycle profits associated with the equipment and secure more continuous streams of revenues.[128] Indeed, while the margins for the initial capital sale of the machine in this mature and highly competitive industry can be relatively low, the life-cycle revenues arising from after-sales services are generally extremely high. As shown in Table 5.2, this is by far the most profitable part of the OEMs' business, accounting for between 50 and 70% of their total revenues and for even higher percentages of profits.[129] Importantly, to capture the profits associated with the after-sales support activities, a number of companies have been established to act exclusively as local and regional service providers for the equipment of established multinational suppliers.

Table 5.2. % of revenues and profits from capital project and after-sales services (selected equipment).

Product line	Value capture's metrics	Stage	
		Capital project	After-sale
Underground drilling machines	Revenues (%)	50	50
	Profits (%)	15	85
Vibrating screens (with screening media)	Revenues (%)	50	50
	Profits (%)	10	90
Feeders, feeder breakers, sizers	Revenues (%)	30	70
	Profits (%)	15	85

Source: Own elaboration based on information gathered through interviews with industry representatives.

Adding value along the mining equipment value chain is not simply a linear process. Rather it encompasses a number of dynamic feedback loops and iterations between later and earlier steps of product development, delivery and service (Hobday 1998, p. 694; Davies, 2004), as shown in Figure 5.3. On the one hand, mining equipment OEMs make sure that components

[128] The total life-cycle cost is measured against all the costs associated with the equipment (i.e., initial capital costs, running and operational costs, and maintenance and repair costs, including operator training). Thus, OEMs and mining companies generally engage in 10 to 15-year contracts, where manufacturers are required to provide not only the necessary equipment, but a whole range of after-sales services: warranties, spare parts provision, maintenance, operator support and training.

[129] Moreover, as reported by industry representatives, it is also one of the most employment-absorbing stages for many OEMs: generally, around three-quarters of total employees are directly involved in after-market support activities.

manufactured in earlier stages of production internally or externally are produced as integrated packages that meet the overall machine design. On the other hand, through a 'learning by using' process (Rosenberg, 1982), the on-site after-sales support teams of the OEMs are able to identify opportunities to improve equipment performance. Indeed, being able to perform internally operational after-sales activities, including maintenance, repair and operations (MRO), is also of primary importance for mining equipment producers because all the information on equipment efficiency, including customer feedback, can become useful inputs into the R&D process and, eventually, lead to revised design for current machines or the development of new products. This is particularly relevant for those service providers that have started from a base of after-market activities and then integrated upstream, moving into system integration and manufacturing.

Complementary technology, advisory and financial services. Besides these main value-adding stages, technology, advisory and financial services support and underpin the creation of value by providing inputs at different stages upstream and downstream. These services can be provided by external entities (Andreoni, 2018), such as intermediate technology institutes, financial institutions and specialised consultants, or by the OEMs themselves (Davies, 2004). In this last case, mining equipment manufacturers develop into high-value integrated solution providers. In addition to an advanced ability to manufacture, integrate and support complex equipment and systems, these companies have also developed a set of novel service capabilities which provide complete solutions to address their end-clients' operational needs.

5.3.3.3 The mining equipment value chain capabilities matrix

The mining equipment capability matrix presented in Table 5.3 has four rows: subcontractors (with basic capabilities), OEMs which simply sell the equipment and replace it on a fail-and-fix basis (with lower-intermediate capabilities), OEMs which provide operational after-sales services (with upper-intermediate capabilities) and high-value integrated solution providers (with advanced capabilities). This sub-section also provides an overview of the capabilities of service providers. However, they are not reported in the matrix since they do not manufacture proprietary equipment and their end-market development and service capabilities closely resemble those of OEMs providing operational after-sales support. As for Figure 5.3, the detailed information reported in Table 5.3 is mainly based on own primary data and insights from the academic literature on CoPS and KIMS.[130]

[130] See footnote 127.

The first step to enter mining equipment GVCs for firms from developing countries is often subcontracting production. This is related to the difficulties in establishing and managing direct relationships with mining companies and project houses. This functional stage might involve subcontracting and assembling work for foreign OEMs, but also for larger local equipment producers with established relationships with end-clients and engineering middlemen (i.e., project houses). Even relatively simple assembling activities have to be performed according to the process and product requirements set by mining companies, project houses and their first-tier suppliers, and they already require relatively high levels of product design and production organisation capabilities. Key requirements include volume, price, quality, reliability, lead times and flexibility, and the strict compliance with specific process, product and safety standards. In fact, certain components and production inputs for mining machines and equipment should present very specific technical criteria, because of the strict durability and resistance requirements associated with operations under extreme conditions.

A second mode of participation in the mining equipment GVCs may involve original equipment manufacturing, where the supplier develops a portfolio of proprietary equipment and machines, and is responsible for financing and sourcing components, system integration and delivering the final product to the designated location for the end-client. This participation model requires some new capabilities in financing and managing the sourcing of components and raw materials, and in dealing with the transport of inputs and delivery of outputs, as well as the related risks. The upgrade from subcontractor to OEM might be related to the gradual development of a domestic mining equipment industry that, in turn, might favour the localisation of inputs sourcing. However, if OEMs rely mainly on imported key components and raw materials, then an increase in working capital as well as a favourable tariff system and some kind of financing mechanism providing them with facilitated access to foreign exchange is required at the country level. Another additional activity that these suppliers have to fulfil is establishing and managing direct relations with mining companies and project houses, and complying with their product, process, safety and local content requirements. The establishment of such direct relations with customers involves the development of basic marketing and communication skills, and the ability to offer corrective maintenance and equipment refurbishment services on a fail-and-fix basis. These are generally managed centrally from the OEM's headquarters.

Some companies may then upgrade towards an OEM model where the supplier designs and develops highly customised bespoke equipment tailored to the specific needs of end-clients.

This requires new advanced capabilities in product development, design and customisation, including investing in virtual simulation and rapid prototyping technologies. As for the previous functional stage, the OEM is responsible for financing and sourcing components, system integration and delivering the final product to the designated location for the end-client. However, these firms have expanded their offering to also include operational after-sales services such as time-based preventive maintenance, web-based condition monitoring and operator training. This obviously requires investing in a distributed network of domestic and regional certified support centres, in the technical and customer service skills of the after-sales personnel, and in those marketing skills necessary to establish deep channels of communications with large mining houses and project houses operating domestically and in the main regional markets of interest. Service providers also have certain product design capabilities, such as customisation, at an upper-intermediate level. Moreover, in addition to the ability to forge partnerships with well-established multinational suppliers of mining equipment technologies, their end-market development and service capabilities closely resemble those of OEMs providing operational after-sales support. Building on their deep relations with local end-clients and on lessons learnt on-site servicing non-proprietary machines, they can strengthen their upstream capabilities as system integrators and manufacturers, establishing themselves as OEMs able to design, engineer and service original proprietary equipment.

Finally, a limited number of mining equipment manufacturers might also develop into high-value integrated solution providers. In addition to an advanced ability to manufacture, integrate and support complex equipment and systems, these companies have also developed a set of novel service capabilities required to provide complete solutions to address their end-clients' operational needs. In particular, these solution providers can make available to end-customers their project management skills and tailor-made vendor financing solutions, as well as a set of complementary resources and technologies like proprietary experimental spaces, global networks of certified training and after-sales support centres, and smart systems for predictive maintenance and warehouse management. This obviously requires substantial financial muscle and the ability to grow and upgrade through strategic mergers and acquisitions (M&A) and joint ventures (JV), as well as organic investments in R&D, supplier development activities and certain advanced skills (e.g., data science, technical sales, equipment finance, project and fleet management, advisory and machine operations). This transition also calls for the build-up of advanced product, process and supply chain coordination capabilities to design and develop modularised and repeatable integrated solutions for different market segments. The ability of these firms to provide integrated mining solutions rather than just machines and equipment also has the effect of deepening their relations with lead mining companies, often to the point of establishing truly global supply alliances and partnerships. Finally, access to facilitated industrial finance and export support, as well as deep collaborative relations with specialised intermediate technology institutes at the domestic ecosystem- or country-level, are also crucial to scaling up from an engineer-to-order model to an integrated solution provider with a global reach.

Table 5.3. Mining equipment GVC capabilities matrix.

Function	Categories of capabilities				
	Investments	Product design	Process and production organisation	End-market development and services	Linkages
Subcontractor / Assembler (*basic*)	• Selection of product(s) and materials (complexity, cost, quality, volume); • Choosing location; • Choosing machinery; • Selection and training of workers (management, technicians, artisans); • Negotiating contracts with utility and service providers (electricity, transport, etc.); • Getting access to investment and working capital; • Getting access to domestic or foreign OEMs; • Factory that is compliant with OEMs' safety, labour, environmental standards.	• Producing according to OEM's requirements and design; • Increasing variety of products; • Shifting to higher value components/machining (complexity, quality, lead times); • Investing in and improving metalworking and finishing equipment;	• Controlling production costs (meeting price points, working capital/inventory management); • Controlling quality (at end of line/multi stage in-line, fulfilling defect/reject rates); • Controlling production reliability; • Controlling production lead times and flexibility; • Machinery, equipment and plant layout maintenance and improvements; • Labour productivity improvements and continuous training;	• Managing relations with OEMs (communication, negotiation, potential audits); • Manage OEMs' diversification • Comply with production and local content requirements of OEMs.	• Managing raw material sourcing; • Links to other firms and collaboration in collective schemes; • Participation in industry association; • Relations with training institutes and consultants; • Link to state support institutions and participation in initiatives; • Negotiating contracts with utility and service providers; • Basic access to working capital finance.
		• Fulfilling volume and variety requirements; • Managing and improving volume flexibility.			
OEM – standard equipment portfolio and outright sale (*lower-intermediate*)	• Getting access to mining houses and project houses; • Selection and training of workers with input sourcing, and clients' communication skills, and with basic design, product development and engineering competences. • Getting access to working capital to assist with R&D, sourcing of production inputs and product development activities.	• Meet minimum quality requirements of targeted markets (e.g., GDMCs, mid-tier traditional; emerging investors; tier 3); • Creating a portfolio of proprietary equipment and machines; • Make-to-order capabilities (following existing fixed design and specifications).	• .Controlling production costs (meeting price points, working capital/inventory management); • Controlling quality (at end of line/multi stage in-line) • Controlling production reliability; • Controlling production lead times and flexibility; • Compliance with end-clients' safety, labour, environmental standards.	• Managing relations with mining houses and/or project houses; • Comply with quality and local content requirements of mining houses; • Managing equipment delivery; • Providing corrective maintenance services (fail-and-fix approach); • Managing corrective corrective services centrally (from headquarter).	• Managing input sourcing and subcontracting linkages (external supply chain management and coordination); • Localisation of input sourcing; • Managing input sourcing and product development finance. *1/2*

Source: Own elaboration based on information from interviews and secondary literature.

Table 5.3. Mining equipment GVC capabilities matrix (*continued*).

	Categories of capabilities				
Function	Investments	Product design	Process and production organisation	End-market development and services	Linkages
OEM – engineer-to-order equipment and provision of operational after-sales services (*upper-intermediate*)	• Selection and training of workers with advanced design, product development and manufacturing engineering skills and with basic marketing skills; • Getting access to working capital to assist with R&D, sourcing of production inputs and product development activities.	• Investing in design capabilities and related instruments (virtual simulation and rapid prototyping technologies); • Provision of design services; • Advanced problem solving, product development and manufacturing engineering capabilities and management; • Improvements in design, product development and manufacturing engineering; • Engineering-to-order capabilities (customisation).	• Controlling production costs (meeting price points, working capital/inventory management); • Controlling quality (at end of line/multi stage in-line) • Controlling production reliability; • Controlling production lead times and flexibility; • Process, equipment and plant improvements; • Continuous training; • Compliance with end-clients' safety, labour, environmental standards.	• Establishing deep channels of communication with domestic mining houses and project houses; • Offering routine and time-based preventive maintenance; • Offering web-based condition monitoring services using manual inputs; • Developing and managing a domestic distributed network of certified support centres; • Offering free trials.	• Managing input sourcing and subcontracting linkages; • Localisation of input sourcing; • Managing finance for input sourcing and product development; • Improving supplier relations and cooperation for product development; • Co-investing with key suppliers; • Supplier development initiatives.
High-value Integrated solution provider (*advanced*)	• Selection and training of workers with advanced skills in design, product development, engineering, data science, marketing, selling, equipment finance and technical sales; • Getting access to working capital to assist with R&D, sourcing of production inputs, product development, equipment finance activities. • Establishing proprietary testing facilities and experimental spaces for R&D, product development and showcases. • Strategic M&A and JVs capabilities.	• Managing product volume and variety (mass customisation, modularisation, use of flexible product control systems for fast project commissioning); • Advanced capabilities for designing and developing repeatable integrated solutions; • Developing different solutions for different end-markets (e.g., establishment of mid-market brands).	• Controlling production costs (meeting price points, working capital/inventory management); • Controlling quality (at end of line/multi stage in-line) • Controlling production reliability; • Controlling production lead times and flexibility; • Process, equipment and plant improvements; • Continuous training; • Compliance with end-clients' safety, labour, environmental standards.	• Establishing global alliances with GDMCs; • Project management skills • Advisory capabilities; • Managing procurement on behalf of the mining house; • Smart predictive maintenance and warehouse management systems and technologies; • Manage end-markets' diversification; • Establishing and managing global networks of certified support centres; • Advanced vendor financing skills; • Investing in market research; • Operating equipment.	• Supplier development initiatives; • Actively creating and supporting new companies through corporate spin-offs; • Advanced supply chain management and coordination capabilities; • Actively orchestrating third parties responsible for the solutions' implementation; • Facilitated access to industrial finance; • Deep relations with local and global intermediate technology institutes .

2/2

Source: Own elaboration based on information from interviews and secondary literature.

The upgrading process described in this sub-section is about the change of an organisational form (Sturgeon, 2002; Lee, 2005; Lee et al., 2015) which, in turn, allows some companies to shift towards more complex and advanced functions. That said, it is important to highlight that what is described here is a stylised and linear representation of an upgrading process that, in practice, may involve very different trajectories and strategic catching-up detours, especially at the lower levels where some subcontractors can develop advanced capabilities in certain specific capability areas (e.g., product design, and process and production organisation) while continuing to have only limited capabilities in other areas (e.g., end-market development and services, and linkages). In this respect, the distinction between advanced, intermediate and basic capabilities employed here does not refer to the complexity of the capabilities developed per se, but to the varying degrees of companies' abilities to develop more diverse and widespread clusters of capabilities and integrate them. Thus, the ordered sequential description employed in this sub-section to characterise selected typologies of companies is not intended to suggest an inevitable linearity between these stages, nor the comprehensiveness of these typologies in the real world.

Rather, the mining equipment GVC capabilities matrix in Table 5.3 captures and disentangles the diverse real-world patterns and dynamics of upgrading and value capture experienced by local suppliers from developing countries and their main foreign competitors. Specifically, it provides the researcher with some additional interpretative guidelines for analysing how a small group of TFSs from advanced economies and emerging Chinese players have been able to exercise different forms of power along this specific sectoral value chain, albeit to varying degrees. The deepening of GVC-specific capabilities, shaped by specific home country factors, has allowed these firms to follow distinctive upgrading paths and at the same time to capture the life-cycle profits associated with the equipment.

On the one hand, this has strengthened their direct bargaining power along mining equipment value chains, increasing dependency on the part of the lead mining companies and project houses, and reshaping the polarity and power configuration within the chain. On the other hand, the building up of these capabilities has allowed these suppliers to reshape the horizontal competition dynamics at the first-tier level. They have been able to exercise increased diffuse and demonstrative forms of power by raising the bar for other mining equipment manufacturers, especially for those in developing countries, by establishing higher de facto standards of operating the chain (see Figure 5.2). In this respect, the information in Table 5.3 helps to identify the sources of the relative success of such powerful foreign suppliers –

namely, their competitive firm- and country-specific ownership advantages (Dunning, 1979a, 1979b, 1981 and 2000) – over local ones, although they all manage to upgrade along the value chain to some extent.

Consistently with the key focus of the present study, this consideration is particularly relevant for a number of middle-income economies where local suppliers operating MHT manufacturing sectors might often fail to capture the value they create through upgrading. It is argued that this relates to their inability to access and control those capabilities and resources complementary to the core technological and production-related ones needed to develop effective commercial strategies. Such inability, in turn, is the result of factors that are both firm- and country- or ecosystem-specific.

5.3.4 Research questions

Against the background of the discussion in the previous sections, this chapter is guided by five overarching research questions.

RQ1. What have been the key sources of the increasing power of TFSs and emerging Chinese actors in the global mining equipment industry over the past two decades?

RQ2. What have been the main effects of such dynamics on the structure of the value chain, its polarity, competition dynamics and the barriers faced by first-tier suppliers in developing countries?

RQ3. Given the evolving competitive landscape within this industry, what is the structure of the South African mining equipment value chain and the prevailing pattern of interactions among key actors?

RQ4. What is the emerging mix of upgrading strategies pursued by South African OEMs over the past few years and which capabilities have they developed?

RQ5. What are the key internal and external factors hindering their potential to capture increasing shares of value from investments in upgrading?

These research questions are assessed empirically in Section 5.5 (RQ1, RQ2) and Section 5.6 (RQ3, RQ4, RQ5).

5.4 Data and methods

To address the research questions outlined above, this chapter employs a mixed methods case study research approach, combining quantitative and qualitative data from (own) primary and secondary sources.

5.4.1 Primary research

5.4.1.1 Research design and instruments

The empirical focus of the present chapter lies on the strategies and processes of building capabilities, as well as on the upgrading paths and value capture trajectories of South African producers of mining machines and their main foreign competitors. Thus, the type of both primary research design and primary data collected in the field should allow for the capture of firm-level processes of decision-making and implementation, as well as the complex interdependences and evolving dynamics within and between heterogenous companies, rather than outcomes per se. To this purpose, a cross-sectional retrospective case study strategy of research has been adopted, collecting information only at one point in time in order to identify both the present situation and past dynamics and changes.

Furthermore, as a research instrument qualitative semi-structured interviews with key informants have been preferred to surveys with pre-coded and close-ended questions mainly focused on 'static' quantitative data. Besides the richness and the depth of the data gathered through semi-structured interviews, a further reason for preferring a qualitative research instrument in this specific situation is of a practical nature: respondents from companies are generally reluctant or even unable – due to formal non-disclosure agreements – to share quantitative figures around turnover, profits, purchasing accounts, procurement, employment structure, wages and, more generally, their balance sheets. However, whenever possible, quantitative primary data has also been collected.

Interviews have been framed around both semi-structured questions and more open-ended questions. This design has ensured that specific topics of interest were covered while enabling the participants to elaborate on other issues freely. Questionnaires have been tailored to the specific characteristics and position within the production system of different actors (e.g., foreign and domestic OEMs, mining companies, project houses, relevant institutions and industry associations). Questions for companies focus mainly, but not exclusively, on their characteristics, main end-markets, activities, functions and skills, supply chain structure and strategies, distribution models, relationships with suppliers, buyers and main competitors, performance and profitability trends, key strengths and weaknesses, and how these different elements have evolved over time according to the transformations taking place globally in the sector.

In particular, information on firms' skills and resources, key strengths and weaknesses, and activities performed are used to assess their capabilities and upgrading paths, while insights to the quality of relations with end-clients and competitors, performance and profitability trends, and internationalisation are employed to formulate an informed qualitative judgement on their value capture trajectories (i.e., increasing, stagnating or declining). Interview questions for relevant institutions and industry associations deal primarily with national policy-related issues and aim to identify the sector's evolution trajectories over time in the country, the main systemic binding constraints and leverage points along the domestic value chain, and how policies and institutions support the related industrial ecosystem. A detailed list of interview topics for a selection of the key firm actors (i.e., OEMs, mining companies, project houses) is reported in Section C.2.1 of Appendix C.

To complement information from interviews with firms, whenever possible, visits to production facilities have been undertaken. During such tours, further insights to production models, firms' capabilities and technical constraints to growth have been captured through direct observation, and short interviews with shop floor managers and employees.

As additional research instruments, graphical tools representing key functions and actors along the mining equipment value chain have been used during interviews in order to better understand the structure of the sector, the relevant players along the chain, their activities and sourcing strategies. The first drafts of the questionnaire and graphical tools were revised on the basis of feedback and comments from some pilot interviews and two focus groups with an industry association. A refined version of the graphical tools employed is reported in Figure 5.2 and 5.3.

As already discussed in Section 2.4 of Chapter 2, the information collected during field research has been particularly useful to contextualise the stylised facts highlighted by previous contributions in the literature and from available secondary data. Moreover, they have allowed for the capture of the evolving dynamics of international fragmentation of production within the global mining and mining equipment industries, the identification of alternative and more appropriate heuristics to analyse the South African mining equipment value chain, the exploration of firms' capabilities and strategies, and the investigation of distinct and complex combinations of causal mechanisms underlining observed events, which may be interrelated and may reinforce each other.

5.4.1.2 Actors interviewed and sample selection process

The key source of primary evidence is represented by 49 in-depth, semi-structured interviews and two focus groups conducted in South Africa between January and October 2019 with relevant actors. A total of 36 interviews were conducted with managers in 24 firms,[131] including eight factory visits.[132] Moreover, seven interviews and two focus groups were conducted with policy officers and representatives of industry associations. Finally, six interviews were carried out with other industry experts (i.e., business consultants, procurement intermediaries). In what follows I list the actors interviewed, elaborating on how they were selected.

Mining equipment producers

For mining equipment producers, selection has been based primarily on the importance of the firm in the market (i.e., market share, linkages with other firms, leader in technological innovation for specific product segments), their ownership characteristics (i.e., multinational non-South African and non-Chinese entities, South African companies and Chinese firms) and their product segment specialisation (e.g., underground mining equipment, surface mining equipment, mineral processing equipment). Initial selection of potential interviewees was based on desk research and firm lists provided by sectoral institutions.[133] Subsequently, the snowballing method was employed to decide which firms should be included in the sample. Snowballing allowed for firms to suggest other strategic firms (i.e., their suppliers, buyers, competitors) or other associations and institutions.

My sample include 28 interviews with managers of 17 key companies producing and/or distributing underground, surface and mineral processing machines for the local and regional markets. Of these 28 interviews:

[131] Of which 17 were mining equipment producing firms, five were mining companies and two were project houses.
[132] The 49 interviews did not include questions asked informally to production personnel or other employees during manufacturing facility visits.
[133] Firm lists provided contact information and some data on production and employment, although not consistently for each firm. The sectoral institutions consulted included the Mining Equipment Manufacturers of South Africa (MEMSA), the South African Mineral Processing Equipment Cluster (SAMPEC) and the South Africa Capital Equipment Export Council (SACEEC).

- Five were with representatives of dominant multinationals with only limited manufacturing and engineering footprints in the country;
- Seven were with representatives of dominant multinationals with significant manufacturing and engineering footprints in the country;
- 14 were conducted with South African companies headquartered in the country; and
- Two were with Chinese firms with local distribution centres, selling assembled or ready-to-assemble machines shipped from abroad.

For each product segment, the final sample includes at least one international market leader, one key South African producer and one emerging Chinese company, if any.[134] Overall, the selected companies represented a substantial share of the domestic market in each product line.[135] Whenever possible, more than one interview per firm was conducted with different relevant respondents, including Chief Executive Officers (CEOs), Managing Directors (MDs), Chief Operating Officers (COOs), Chief Technical Officers (CTOs), and engineering, sales, business development, supply chain and procurement managers. Of the 17 companies scrutinised, eight also opened the doors of their manufacturing facilities and allowing for in-depth shop-floor visits.

Mining companies

For mining houses, selection was based primarily on the size of the company (i.e., GDMC, mid-tier, tier 3) and the origin of their ownership (i.e., traditional investors and emerging investors). The information and contacts shared by mining equipment producers guided this selection process. Interviews with mining houses and project houses (see next sub-section) enabled triangulation of the information on the global and domestic evolution of the sector provided by buyers with that shared by suppliers. Out of the ten mining houses contacted, only half responded. Five interviews were conducted with current or former executives close to the decision-making process with regards to supply chain management at five different mining houses, of which one was a GDMC, two were mid-tier companies and the remaining two were tier 3 players. This variation in firm size allows for the exploration of differences in

134 According to own interviews Chinese OEMs still lag far behind major foreign producers and many local suppliers with respect to underground mining solutions. I was not able to access any major Chinese producer operating in South Africa in this product segment.

135 In particular, for the underground mining equipment segment the companies interviewed together have a cumulative market share of over 70% (Smeiman, 2018; Interview 014367). Moreover, one of them alone accounts for around 80% of the specialised coal machines local market. Much less accurate information is available for surface and mineral processing equipment, however, from our primary data is possible to infer that the interviewed companies account for substantial shares in their specific markets.

their sourcing strategies and value chain governance structures. Furthermore, three of them were owned by international investors from North America and United Kingdom, while two were South African.

Due to practical difficulties, notwithstanding efforts made during the fieldwork, it has not been possible to access mining companies with significant or majority Chinese ownership in the country. This substantial limitation prevents any direct comparison between Chinese and other buyers or any triangulation with information shared by suppliers. As a result, differences in the sourcing strategies and value chain governance between international and Chinese investors are inferred from information gathered through interviews with OEMs and project houses interacting with different types of mining houses. This indirect data is then compared with findings from previous, closely related works (Fessehaie, 2012a; Fessehaie and Morris, 2013; Tull, 2006; Zeng and Williamson, 2007) to test the validity of the results in the present study.

Project houses

As for mining companies, the selection of project houses was based primarily on the information and contacts shared by mining equipment producers. Three interviews were conducted in two different companies. Of these, two were carried out with representatives of a prominent South African firm with a significant global footprint. The remaining interview was conducted in an international specialised mining engineering contractor.

Public and private sector institutions

All the relevant private sector organisations were contacted and eventually four of them were interviewed: namely, the Mining Equipment Manufacturers of South Africa (MEMSA), the South African Mineral Processing Equipment Cluster (SAMPEC), the South Africa Capital Equipment Export Council (SACEEC) and the Mineral Council of South Africa (MCSA). Through them six relevant public officers within the Department of Trade and Industry (DTI), the Department of Science and Technology (DST), the Department of Mineral Resources (DMR) and the Mandela Mining Precinct (MMP) were identified and eventually three of them interviewed. Both private and public organisations also provided valuable relevant, unpublished documents and reports, and suggestions for strategic firms to target.

Other relevant industry experts

Finally, six interviews were carried out with industry experts, such as mining technology consultants and procurement intermediaries, with former professional experience within leading mining companies, project houses and mining equipment manufacturers. In particular, one of the companies interviewed was a South African China-focused global procurement firm providing a comprehensive range of services across the supply chain and, in particular, with respect to the sourcing of raw materials, components, engineered equipment and services from China.

The case studies reviewed in Section 5.6.3 were chosen from locally owned South African companies. Interviews with other players were used mainly to analyse the strategies and position of core multinational and Chinese companies within the sector; the related restructuring dynamics at global, regional and domestic level; and the pattern and quality of interactions prevailing within the South African mining equipment industry.

Due to time and financial constraints, it was not possible to perform a full survey and a strategic choice of the actors to be targeted was preferred as a selection approach. Specifically, I adopted a non-probability purposive and snowball sampling approach (Hibberts et al., 2012), and I stopped interviewing after saturation was reached (Glaser and Strauss, 1965; Yin, 2009). This type of case study approach, primarily based on semi-structured interviews with key informants and experts, comes with a number of limitations: case selection bias, subjective conclusions, limited estimation of causal weight of variables, lack of representativeness and non-replicability, among others (Gerring, 2004; George and Bennet, 2005).[136]

However, this chapter does not claim to provide a statistically representative overview of the sector, but rather to identify the overarching dynamics shaping the structure of the industry at the global level, and how these transformations might influence both strategies and processes of capability building, upgrading paths, and value capture trajectories of key foreign and local OEMs. In this regard, selection bias has in fact taken place in order to pick precisely the most strategic and successful firms operating in the mining equipment sector, both globally and in South Africa.

Moreover, the chapter does also not intend to estimate the significance or weight of key variables of governance, competition, value creation and value capture, but is interested to understand the causal relations (the 'why' question) and dynamics (the 'how' question) taking place (Yin, 2009). The mixed methods case study approach, conducted through purposive and

[136] However, in this case, the lack of representativeness is partially mitigated by the relatively small size of the specific industry and market under consideration (i.e., the actual population of mining equipment companies operating in South Africa does not consist of tens of thousands of companies as in very large developed and emerging economies).

snowball sampling techniques, and involving a substantial qualitative component, is a particularly good method for capturing such insights.

Furthermore, the typical methodological limitations associated with semi-structured interviews, such as respondents' understanding and respondents' provision of genuine statements (Lawson, 2006b, pp. 192-193), have been checked for – and possibly balanced out – through two different mechanisms: triangulation and follow-up questions. First, triangulation allowed information validity, accuracy and exhaustiveness to be ascertained by confronting the data provided by buyers, suppliers, project houses and other actors on the same subject matter. This exercise made it possible to identify inconsistencies that, in turn, may provide key insights on the quality of value chain linkages and reveal possible misalignments (Kaplinsky and Morris, 2001; Schmitz and Knorringa, 2000). Second, follow-up questions have been used to test the legitimacy and extensiveness of earlier answers, as well as the willingness of respondents to elaborate on various subjects and/or their direct experience with them. In particular, this last strategy has made it possible to avoid as much as possible relying on vague and incomplete information provided by third parties.

5.4.1.3 Additional considerations on data collection and analysis

Most of the interviews took place in Johannesburg or in the close vicinity, due to the geographical concentration of the mining equipment sector within the Gauteng province. Official requests for interviews were sent to the target firms by email, introducing the researcher and the research project, outlining the main issues to be covered in the interview, and guaranteeing confidentiality of the data provided. The DTI in South Africa also endorsed the research project, raising its profile and, consequently, the rate of response to my interview requests (see Figure C.2.2.1 in Section C.2.2 in Appendix C on this: it shows an introduction letter drafted by the DTI promoting the research project related to this study).

All interviews were conducted in English and lasted between 45 minutes and 3 hours for both firms and other relevant actors (excluding factory visits), depending on the willingness and appropriateness of the interviewee. They were recorded – whenever possible and permitted by express consent – then fully transcribed and analysed through inductive coding, namely constructing themes and patterns, and extracting perceptions and relations from transcripts (Bernard, 2011; Glaser et al., 1968). All interviews have been anonymised and they are referred to throughout the text with an identification code.

5.4.2 Secondary research

Primary data is triangulated with secondary quantitative and qualitative information to check for inconsistencies and overlaps. I made use of publicly and non-publicly available industry-, product- and firm-level quantitative data provided by Statistics South Africa, Quantec, fDi Markets, UN Comtrade, OECD-TiVA database and the SARS data. These sources report statistics on output, employment, exports and imports, trade in value added and FDI flows, as well as detailed figures on firms' income, expenditure, equity and liabilities, capital items and assets.

This material is complemented by qualitative and quantitative insights gathered through an in-depth analysis of both earlier academic contributions and reports prepared by companies, industry associations, think tanks and government agencies. Specialised magazines like *Mining Weekly*, *Engineering News*, *Mining Global* and *International Mining*, among others, are employed as additional sources of qualitative and quantitative evidence. All this material is used to track major sectoral and corporate developments in the global mining equipment industry, and to position the South African production system within it.

5.5 Global restructuring dynamics in the mining equipment industry

To address RQ1 and RQ2, Sections 5.5.1 and 5.5.2 examine the key reorganisation trajectories that have taken place at the global level within the industry in the last two decades, shedding light on how a small group of large TFSs and emerging Chinese actors have played an increasingly influential role in the functioning of mining global value chains.

5.5.1 The role of powerful transnational first-tier suppliers

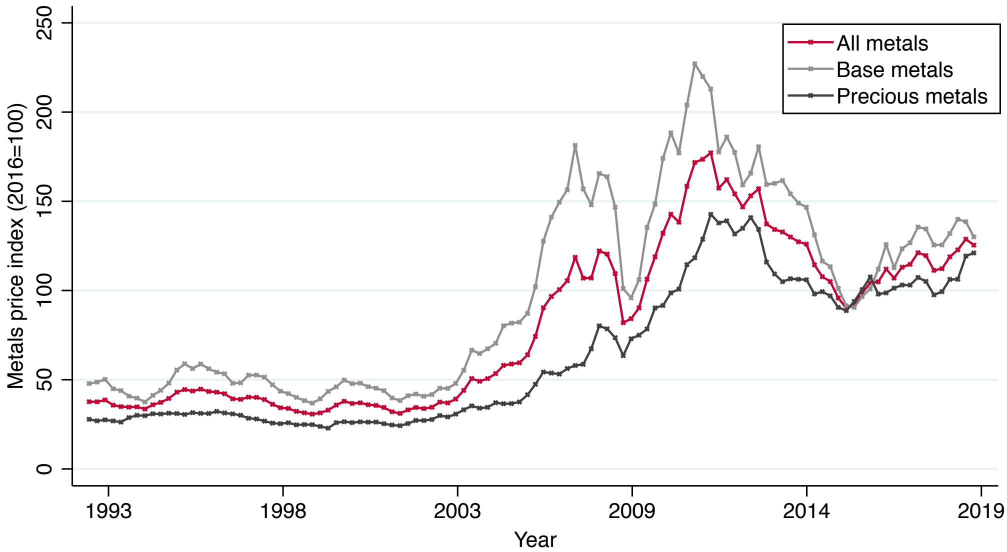
Since the early 2000s, a small group of large multinational manufacturers of mining equipment and machinery have played an increasingly influential role in the functioning of MGVCs. The growing importance of these TFSs reflects their responses to the evolving global dynamics affecting the mining industry, as well as the shifting strategies of their traditional top-tier customer base, mainly represented by GDMCs. Over time, TFSs have gained a dominant position within the chain as high-value integrated solutions providers through a number of strategic initiatives (e.g., M&A, JV, organic investments) that allowed them to access and control specialised complementary resources.

In what follows, primary and secondary information have been combined to analyse the sources and effects of their increased power in the industry. First, I show how the globalisation and consolidation of TFSs have been actively encouraged by a number of demand-side dynamics and in particular by the shifting procurement strategies of large GDMCs. Then, I review the transition process of TFSs towards high-value integrated solution providers as well as the implications of their increasing power on the structure of the value chain, and on both end-clients and competing first-tier suppliers.

5.5.1.1 Globalisation, concentration and consolidation of GDMCs

The global mining industry at the dawn of the 2000s was already quite concentrated and international (Urzua, 2013; Humphreys, 2015). However, it was only during the commodity boom between 2004 and 2012 reported in Figure 5.4 that a small group of large GDMCs emerged, through a series of M&A conducted mainly between 2005 and 2007.

Figure 5.4. Indices of metal commodity prices 1992-2019.

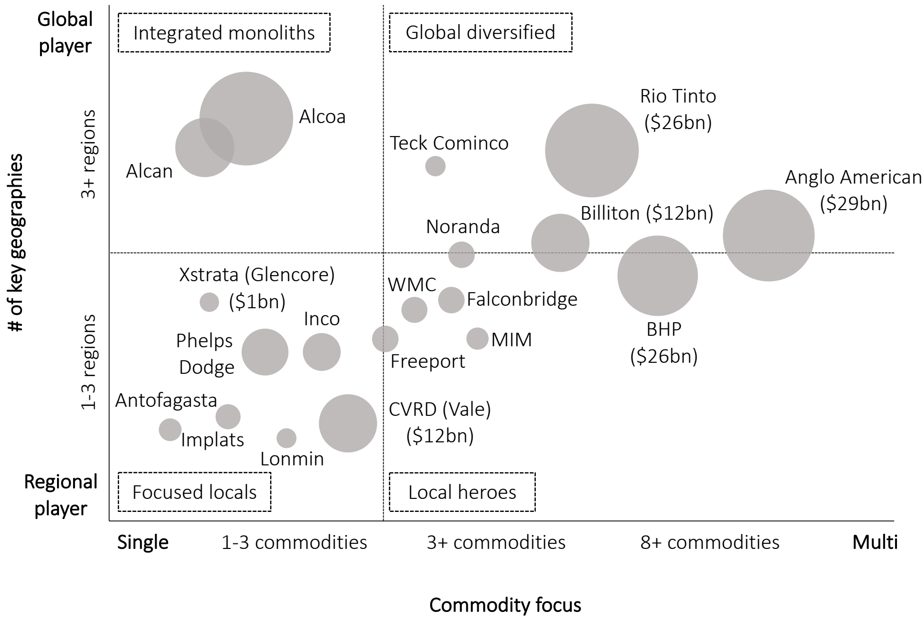


Notes: Base metals group includes aluminium, cobalt, copper, iron ore, lead, molybdenum, nickel, tin, uranium and zinc; precious metals group includes gold, silver, palladium and platinum.
Sources: IMF, World Economic Outlook Report, various editions.

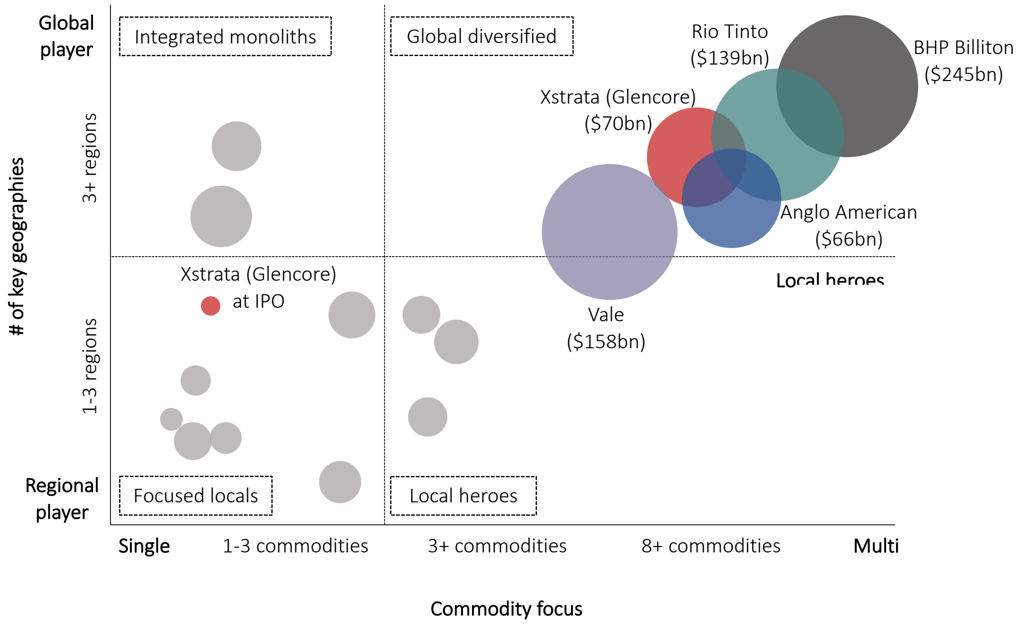
As a result of this consolidation, many middle-ranking mining companies disappeared and the industry became increasingly dominated by a handful of large multi-mineral mining companies with worldwide operations (Shapiro et al., 2007; Humphreys, 2015; PwC, 2018 and 2019). Figure 5.5 shows this transition.

Figure 5.5. The global mining industry in 2001 (a) and in 2011 (b).

a) 2001



b) 2011



Note: Quadrant titles are from the original Xstrata's presentation, reported by Scott-Kemmis (2012). Bubble sizes represent market capitalisation as at January 2001 (a) and at May 2011 (b).
Source: Own elaboration base on Xstrata's data reported by Scott-Kemmis (2012).

The structural power of these lead firms is reflected in their level of market capitalisation. In 2018, the top five diversified mining companies – BHP Billiton, Rio Tinto, Vale, Glencore and

Anglo American – made up 50% of total market capitalisation of the top 40 companies (PwC, 2019).

The emergence of GDMCs during the commodity boom is explained by the ongoing globalisation of the economy itself, the renewed interest of large institutional financial investors in mining activities and the advances in technology. The latter, in particular, enabled miners to dismantle the practical challenges of operating globally. Improvements in communications, computerisation and web-based technologies allowed GDMCs to achieve economies of scale in their financial management, marketing and procurement activities, and to develop a so-called 'one-company' policy to increase the coherence of their international organisation (Humphrey, 2015).

While the materiality and landed nature of resource extraction activities (Bridge, 2008) would suggest a high level of local embeddedness of lead mining firms (Morris et al., 2012), these restructuring dynamics have resulted in a partial de-territorialisation of their supply chain (Parker et al., 2018). In particular, the spread of centralised procurement practices has facilitated and enhanced an increasingly global approach to supplier relations (Interview 042347). This sourcing policy was further strengthened by the emphasis on capital conservation, lifecycle cost reduction and value-based management practices characterising the period of weaker commodity prices immediately after the end of the super-cycle (Parker et al., 2018, Interview 041154).

Over time, GDMCs have standardised entire fleets and suites of equipment across their global operations, rationalising their supplier base by keeping only few, larger and far more strategic first-tier suppliers able to meet their global needs locally and to offer complete integrated solutions (i.e., 'global sourcing follower supply' pattern of chain organisation).[137] This allowed GDMCs to simplify their external interactions and to maximise production efficiency by ensuring economies of scale in training, maintenance and repair activities, encouraging, at the same time, a process of consolidation and globalisation of the supplier base (Interviews 025392, 041099 and 042347).

[137] GDMCs outsource non-core activities to the most reliable and lowest cost suppliers ('global sourcing'). At the same time, the geographically dispersed nature of GDMCs' operations required core suppliers to locate their support centres in close proximity to the mines to ensure next-day delivery of spare parts, on-site maintenance, training provision and so on ('follower supply'). This, in turn, motivates the need for local supply, but not necessarily provided by locally owned firms. In contrast, strategic international suppliers follow GDMCs into their global operations, adding value locally through after-sales services, but generally without establishing a significant local base for engineering and manufacturing operations (Urzua, 2013; Morris et al., 2012; Interview 042347).

5.5.1.2 TFS' consolidation and upgrading to high-value integrated solution providers

By 2006, it has been estimated that the leading six global mining machinery manufacturers accounted for about a quarter of total world production: Atlas Copco[138] and Sandvik from Sweden; Bucyrus International, Joy Global, Terex Corp from the USA; and Metso from Finland (Deneen and Gross, 2009). Table 5.4 reports a selection of ten major TFSs operating in the sector today. These companies have been identified through extensive desk-based research and interviews with industry experts. Together they cover around 50% of total global demand for heavy construction and mining equipment.[139] These companies are all headquartered in advanced economies, characterised by strong systems of innovation and financial networks. They generally perform the bulk of R&D and engineering activities in their home countries, while having a significant international footprint in terms of manufacturing, assembling, distribution and after-sales operations.

Table 5.4. Selected major mining machinery and equipment manufacturers, 2019-2020.

Company	Origin	2019 Revenue (USD billion[a])	Market Cap (USD billion)	Employees (000s)	Main products lines[b]
Caterpillar	USA	53.80	56.06	102.30	Mining, constr. equipment
Komatsu	Japan	23.87	15.67	61.91	Mining, constr. equipment
Sandvik	Sweden	10.70	16.55	41.29	Rock excavation equipment
Hitachi	Japan	9.20	4.32	24.59	Mining, constr. equipment
Terex	USA	4.35	1.13	9.50	Lifting, mineral processing
Epiroc[c]	Sweden	4.23	11.01	14.27	Mining equipment, tools
Weir Group	UK	3.28	2.84	17.52	Slurry handling equipment
FLSmidth	Denmark	3.10	1.24	11.77	Mineral proc. equipment
Outotec[d]	Finland	1.36	0.66	4.05	Mineral proc. equipment
Metso	Finland	0.74	3.55	2.93	Mineral proc. equipment

Notes: [a] Trailing 12 months (TTM), data accessed from following source on 16 March 2020. [b] For some companies, financial data and employee figures refer also to non-mining related product lines. [c] Since 2018, flowing its separation from Atlas Copco Group, Epiroc operates as an independent company focusing on customers in mining, infrastructure and natural resource industries. [d] On 4 July 2019, Outotec announced the acquisition of Metso's minerals division (i.e., Metso Minerals). All non-USD values converted to USD using xe.com on 16 March 2020.
Source: https://markets.ft.com/data/equities.

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[138] Now the group is subdivided into two listed entities, with Atlas Copco focusing on industrial customers and Epiroc focusing on customers in mining, infrastructure and natural resource segments. The rest of the chapter focuses on the latter entity.

[139] Some caution is needed since this figure is based on own estimates combining a number of different data sources. Secondary information includes data accessed through Euromonitor International, available at http://www.portal.euromonitor.com, and companies financial profiles accessed through the Financial Times Market Database, available at https://markets.ft.com/data/equities; primary data refers to interviews with industry representatives and experts conducted in South Africa in 2019 (Interviews 012398, 017703 and 062765).

The upgrading of these TFSs toward high-value integrated solution providers has been achieved through the accumulation of advanced sectoral GVC-specific capabilities, control over specialised and co-specialised complementary resources, and the internalisation of a set of key functions and activities to fully address their end-clients' operational needs.[140]

a. Building up high-value integrated solution providers' capabilities

Over time, TFSs have increased the range of tasks performed within the chain. In particular, the shifting of responsibilities from GDMCs to TFSs led to the latter upgrading their capabilities in supply chain management and production organisation, in the provision of advisory and technology services, and in the offering of equipment vendor financing packages.

By taking over supply chain management and coordination functions, TFSs have improved efficiency in the production cycle. They can rely on their structured supply chain consisting of a global network of manufacturing facilities located in their home countries and abroad. This provides them with the flexibility to assess from time to time, on a landed-cost basis, where it is convenient to do the fabrication for different product lines, also taking into consideration the geographical location of the specific mining project and the requirements imposed by the customers (e.g., minimum local or regional content, price criteria, specific preferences over components' brand or origin). TFSs have also been able to exploit digital data advances to develop cutting-edge proprietary technologies for organising and coordinating their extremely complex networks of suppliers, manufacturing facilities and customers. Through these technologies, they have streamlined the order-production-delivery process, managing variability and disruptions, and effectively reducing inventory costs (Interviews 025390, 025567, 025876 and 057802). With respect to the organisation of the production flow, mass customisation principles like standardisation, modularisation and the use of product configuration systems have become crucial for optimising the engineering and sales processes, and, ultimately, for increasing competitiveness and value capture, especially in large international projects led by GDMCs (Interviews 025392 and 025395).

The increasing demand on the part of GDMCs for complete solutions has also prompted TFSs to develop the project management capabilities to design, execute and operate large mineral processing plants through innovative risk- and ownership-sharing leases (Interviews 025391,

140 These are reported in the last row of the mining equipment GVC capabilities matrix in Table 3.

025392 and 057801).[141] Mineral processing TFSs, like FLSmidth, Metso and Outotec, have started to offer specialised technical advisory services, establishing their own PS (Engineering, Procurement and Service) project delivery models. Other TFSs also operate their machines and equipment as external contractors, on behalf of the end-client (Interview 025572).

Many of these have also invested in internal technical sales skills, and established in-house financing organisations to provide their customers with innovative and flexible finance and leasing packages (Interview 025391 and 025567).[142] These options represent effective ways to change the distribution of investments between capital and operating expenses in the end-clients' financial model, allowing them to easily move resources from CapEx to OpEx. In many instances, the relationship between these TFSs and their home countries ensures that they have improved and simplified access to development and export finance institutions, which in turn provide them with state-sponsored export credits at low interest rates (Interviews 012398 and 062001). TFSs have also managed to increase their power in MGVCs by controlling and leveraging critical and appreciating specialised complementary resources such as distribution channels, after-sales support networks, proprietary testing and R&D facilities.

They have established widespread networks of local sales and support offices that are generally managed by owned subsidiaries (e.g., Komatsu's model), or by independent dealers (e.g., Caterpillar's model). Given the materiality and landed nature associated with mining activities (Bridge, 2008), proximity to the end-client is crucial, and this is why sales, distribution and support centres are generally geographically located close to, or even inside, mining operations (Interviews 041154 and 042347). Through these facilities, TFSs manage all after-sales service activities, including installation, training of machine operators, provision of spare parts, maintenance, repair, refurbishing and re-building. The geographical remoteness of mining operations also increases the benefits of adopting predictive maintenance solutions rather than time-based maintenance programmes, since the former allow for performing maintenance only when needed, but before unplanned breakdowns can occur on site. TFSs' machines are equipped with proprietary intelligent monitoring technologies, providing timely and efficient machine health and performance information, and recognising familiar patterns and deviation from normal control limits (Interviews 025567, 025572 and 025793). These technologies and the use of advanced analytics also strengthen and accelerate the dynamic feedback loops and

141 Examples include the Build, Own, Operate and Maintain (BOOM) and the Build, Own, Operate and Transfer (BOOT) models of project delivery.
142 Examples include financial and operational leases, low-interest loans, trade finance solutions and short-term rental packages including or excluding services (International Mining, 2019a and 2019b).

iterations between later and earlier steps of product development, delivery and service, providing important and real-time inputs to R&D processes.

TFSs, indeed, devote significant resources to R&D activities, including standardisation and certification, product design, prototyping and scaling up, process development and engineering. In particular, over the past decade, they have invested substantial resources in proprietary support infrastructures such as test mines and research centres. These facilities allow them to develop and test solutions in a real-world mining environment without impacting on the daily operations of their customers, and to offer them additional services such as training sessions, showcases and demonstrations. Often, such facilities serve as a platform for companies to directly engage and collaborate with mining houses and engineering contractors, as well as intermediate government-funded institutions and universities in their home countries (Interviews 042347, 025132 and 025876).

b. Growing and upgrading through strategic M&A

The upgrading of TFSs towards high-value integrated solution providers has been achieved through organic investments, but also via acquisitions and partnerships. In particular, from the early 2000s onwards, in response to the changed demand environment, in many instances equipment manufacturers decided to take a shortcut to volume growth, global reach, and product segment and function diversification through a series of strategic M&A and JVs (Humphrey, 2015). Since the early 2000s, the sector has undergone a tremendous consolidation process: large and well-funded multinational companies have continued to grow, acquiring other firms, building up production and distribution networks around the globe to serve their global top-tier clients. At the same time, they started to streamline and focus on core activities, disposing of their non-strategic assets in other industries (Interviews 025391 and 025392).

Table 5.5 reports representative examples of these strategic transactions, grouped by the main driving motivation: (*i*) increasing production capacity, (*ii*) developing complementary capabilities to enter new product segments, (*iii*) new functions and (*iv*) new markets, and (*v*) acquiring complementary technologies.

First, 'peer' firms were acquired with the aim of increasing production capacity in the core products segments, especially during the commodity boom. For example, as part of its aggressive capacity expansion plans, in 2011 Caterpillar acquired the mining equipment division of Terex through the purchase of Bucyrus International, strengthening its position in the provision of surface earthmoving mining machines (Interview 014367). Similarly, FLSmidth purchased Conveyor Engineering in 2009 to acquire the know-how to manufacture high-capacity large bulk material handling systems (Interview 025392).

Second, at the same time many transactions have been conducted to enter new product segments and chain functions in order to offer a broader range of equipment and services to GDMCs. This wave of acquisitions has allowed TFSs to respond to the increasing demand on the part of mining companies for an integrated solution approach. Caterpillar's acquisition of Bucyrus International in 2011 and Komatsu's purchase of Joy Global in 2017, together with P&H Mining Equipment and Montabert,[143] have allowed these two giant multinationals to offer a full suite of equipment for both surface and underground mining operations (Interviews 025567 and 025572). From 2005 to 2015, through over 25 strategic acquisitions, FLSmidth has built complete float sheet competences in mineral bulk handling and processing equipment for many commodities, such as copper, gold, coal and iron ore (Interviews 025391 and 025392).

Third, especially in the mineral processing space, a number of TFSs have acquired the assets of engineering and construction companies in order to provide the market with an option to procure complete proprietary solutions. An example is the acquisition by FLSmidth of CEntry Constructors & Engineers in 2008 (Interviews 025391 and 025392). Also, Outotec and Metso Minerals recently announced their transformational combination. While enhancing production capacity and synergies, this transaction will also enable the new company to strengthen its service expertise, offering more integrated customer solutions.

Other transactions have been aimed at both entering new emerging markets and developing mid-price equipment brands for the tier-3 customer-base. In particular, numerous M&A and JVs have been conducted with Chinese manufacturers over the past decade. Examples include the acquisitions of Shandong Rock Drilling Tools by Epiroc and Quzhou Juxin Machinery by Metso, which were designed to enhance the firms' position in the Chinese and other Asian-Pacific markets (Interviews 025567, 025390 and 025876).[144]

Finally, more recent transactions have been aimed at acquiring complementary intellectual property and technologies to meet stricter safety and environmental standards, and to discover and exploit more marginal resources at a greater depth and under more extreme circumstances. Examples include battery electric vehicle solutions for underground mining, autonomous

[143] In 1994, Harnischfeger Industries (later known as P&H Mining Equipment) purchased Joy Mining Machinery. In 2015, Joy acquired Montabert.

[144] See Section 5.2.3 and Table C.3.1 in Appendix C for further details on this.

vehicles, predictive maintenance and simulation training systems (Interviews 014367 and 025132).

Table 5.5. Selected examples of strategic M&A by TFSs in the mining equipment industry.

Main M&A motive	Representative examples			Description
	Acquirer	Acquired / target	Year	
Increasing production capacity	Metso	Svedala Industri	2001	Rising production capacity in mineral processing machines.
	FLSmidth	Conveyor Engineering, EEL India Limited	2009	Acquiring know-how to design and manufacture major bulk material handling systems.
	Caterpillar	Terex (mining), through Bucyrus International	2011	Rising production capacity in surface heavy earth moving equipment.
Developing complementary capabilities to enter new product segments	FLSmidth	GL&V Process, Roymec, Knelson, Ludowici, Sandvik Mining Systems	2005-2018	Building complete float sheet capabilities in mineral handling and processing ('pit-to-plant' strategy).
	Caterpillar	Bucyrus International	2011	Strengthening firm's position in underground equipment.
	Komatsu	Joy Global, P&H, Montabert	2017	Strengthening firm's position in underground equipment.
	Epiroc	Fordia, New Concept Mining	2018	Strengthening firm's position in exploration drilling tools and hard rock bolting market.
Developing complementary capabilities to enter new functions	FLSmidth	CEntry Constructors & Engineers	2008	Strengthening EPCM skills and capabilities to offer complete proprietary solutions.
	Outotec	Metso Minerals	2019[a]	Strengthening synergies and EPCM skills to offer complete proprietary solutions.
Entering new mining centres in emerging countries	Epiroc	Shandong Rock Drilling Tools	2013	Strengthening firm's position in the Chinese market for mining consumables.
	Metso	Quzhou Juxin Machinery, Quzhou Chixin Machinery	2013	Strengthening firm's position in China and other Asian-Pacific markets, for mining wear parts.
Acquiring new complementary technologies	Epiroc	ASI Mining (34%)	2018	Acquiring new technology solutions for the autonomous operation of mining vehicles.
	Sandvik	Artisan Vehicle Systems	2019	Acquiring new technologies and capabilities to enter market for battery electric vehicle solutions.
	Sandvik	Newtrax Technologies	2019	Acquiring new technologies and capabilities to strengthen firm's position in automation and digitalisation areas.
	Komatsu	Immersive Technologies	2019[a]	Acquiring new technology to optimise safety and efficiency of equipment operators.

Notes: [a] Acquisitions announced but not completed yet.
Source: Own elaboration, based on interviews, companies' annual reports and specialised magazines' articles.

5.5.1.3 Implications for chain polarity and horizontal competition along MGVCs

Through these strategic initiatives, TFSs have been able to improve their bargaining powers with regard to the dyadic relationships with lead mining companies and project houses, along the vertical GVC dimension. They have successfully altered the forms of governance to which they are subject, moving from captive towards relational arrangements, increasing dependency on the part of the end-client. They have been able to effectively capture the value they create by investing in upgrading, by means of acquiring and integrating a wider set of advanced capabilities, performing increasingly complex functions, entering new markets, increasing production capacity, building up and 'orchestrating' a global supply chain, and investing in specialised complementary resources. This, in turn, has enabled them to generate a decisive shift in the value chain polarity of MGVCs.

Specifically, within the underground and surface mining equipment space, bipolar types of governance tend to prevail today along MGVCs characterised by lead GDMCs and key strategic TFSs. In the mineral processing segment, tripolar governance structures, including powerful middlemen (i.e., project houses), are more common. However, the dependency of lead mining companies on large project houses is declining since many mineral processing TFSs have started to offer complete proprietary solutions to their customers through the provision of specialised in-house design and engineering services. As a result, these chains are also gradually moving towards bipolar forms of governance (Interviews 057802 and 025392).[145]

These relations between lead mining companies and specific entrusted TFSs have become extremely deep and complex, often to the point of constituting truly global alliances and partnerships, further strengthening TFSs' market position. These companies, indeed, have the ability to influence the functional and technical specifications associated with the mining system conceptualised during the technical and financial evaluation stages of the mining investment project, giving their equipment a significant competitive advantage in the tender phase. This, in turn, allows to minimise risk exposure of end-clients, maximising their production efficiency and ensuring economies of scale in maintenance activities. In fact, once a TFS has secured a contract for supplying equipment and related services, it is far simpler and less risky for the mining house to maintain the status quo than to move to another supplier. According to interviews with end-client representatives, a very strong strategic intent of the

[145] A consequence of this shift is also the emerging competitive tension among project houses and certain mineral processing TFSs. These companies are increasingly perceived by the engineering contractors as competitors in the projects or complete systems space, rather than suppliers of equipment.

top-level management would be needed to change entire suites of mining equipment, shifting to alternative, maybe local, suppliers, especially for brownfield operations (Interviews 042347 and 041099). Thus, the emerging multipolarity characterising MGVCs also has implications for the TFSs' relations with other equipment firms, and it suggests the need to look beyond lead firm-supplier relations to examine the relations between competing suppliers as well.

Through the strategic initiatives reviewed here, large TFSs have been able to establish higher de facto requirements for operating the chain. This, in turn, has intensified the competitive pressure they exert on other equipment producers, either existing players or new entrants to the industry. A key implication of the rise of powerful TFSs and the shift in chain polarity along MGVCs led by GDMCs is that the space for the emergence and further long-term expansion of local suppliers from developing countries has gradually shrunk. However, as detailed in the following section, in the case of China, a number of indigenous equipment manufacturers are becoming globally competitive, gaining significant market shares.

5.5.2 The dynamics of China's participation and upgrading in mining equipment GVCs

Unlike most firms from developing countries, over the past two decades Chinese OEMs have been able to benefit from an explicit strategic intent of the Chinese government to create competitive national champions in the construction and mining equipment sector, and from the large and increasing size of the domestic market for these technologies. In what follows, I explore the dynamics of China's participation and upgrading along multiple mining equipment GVCs, as well as the related strategies and processes of building sector-specific capabilities. In the final sub-section, the implications of the rise of Chinese OEMs along multiple mining value chains is discussed, with specific reference to the impact on other mining equipment manufacturers, either TFSs or from other emerging economies.

5.5.2.1 Setting the scene: China's production, trade and GVC figures

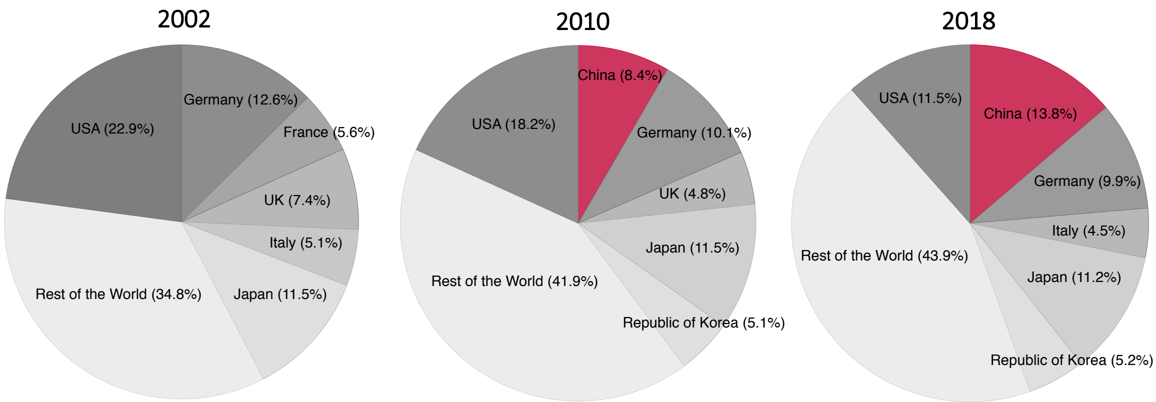
Over the past two decades, the production of mining equipment[146] in China has grown rapidly. Starting from rather modest levels in the early 2000s (around USD 5.2 billion), at the height of

[146] Production and trade data do not always allow for figures on mining and construction machinery to be obtained separately. This is because many earthmoving machines used for surface mining are also employed in the construction industry. In what follows, secondary data on production makes reference to the broader class of manufacture of machinery for mining, construction and quarrying (ISIC 2924). Although ISIC 2924 does include construction equipment, the majority of the equipment covered is mining specific. For trade data, some efforts have been made to exclude products at 6-digit mainly used in construction. A list of included products is shown in Section C.1.2 in Appendix C.

the commodity boom in 2008 it increased by more than eight times, reaching USD 43.8 billion. By 2011 China had emerged as the world's largest producer of machinery for mining (USD 77.5 billion), while production in the USA had fallen (from USD 44.3 billion in 2008 to USD 41.3 billion). During the same period, other major producers, like Japan and Germany, experienced a decline in their production levels: from USD 26 billion to USD 23.6 billion and from USD 24.5 billion to USD 15.8 billion, respectively (Farooki, 2012).[147]

In 2016, China also became the largest exporter of mining machinery, up from fourth position in 2010. In 2002, its exports of mining machinery and equipment (USD 302 million) accounted for a negligible 0.9% of total world exports. Over the following 16 years, China's share in global exports increased by just under 13 percentage points, to reach 13.8% in 2018, equivalent to around USD 16.1 billion in absolute terms. As shown in Figure 5.6, during this period, the country has gradually outperformed other major exporters such as the USA, Japan, Germany, Italy and the Republic of Korea.

Figure 5.6. World export shares in mining equipment: top six exporters and rest of the world, selected years.



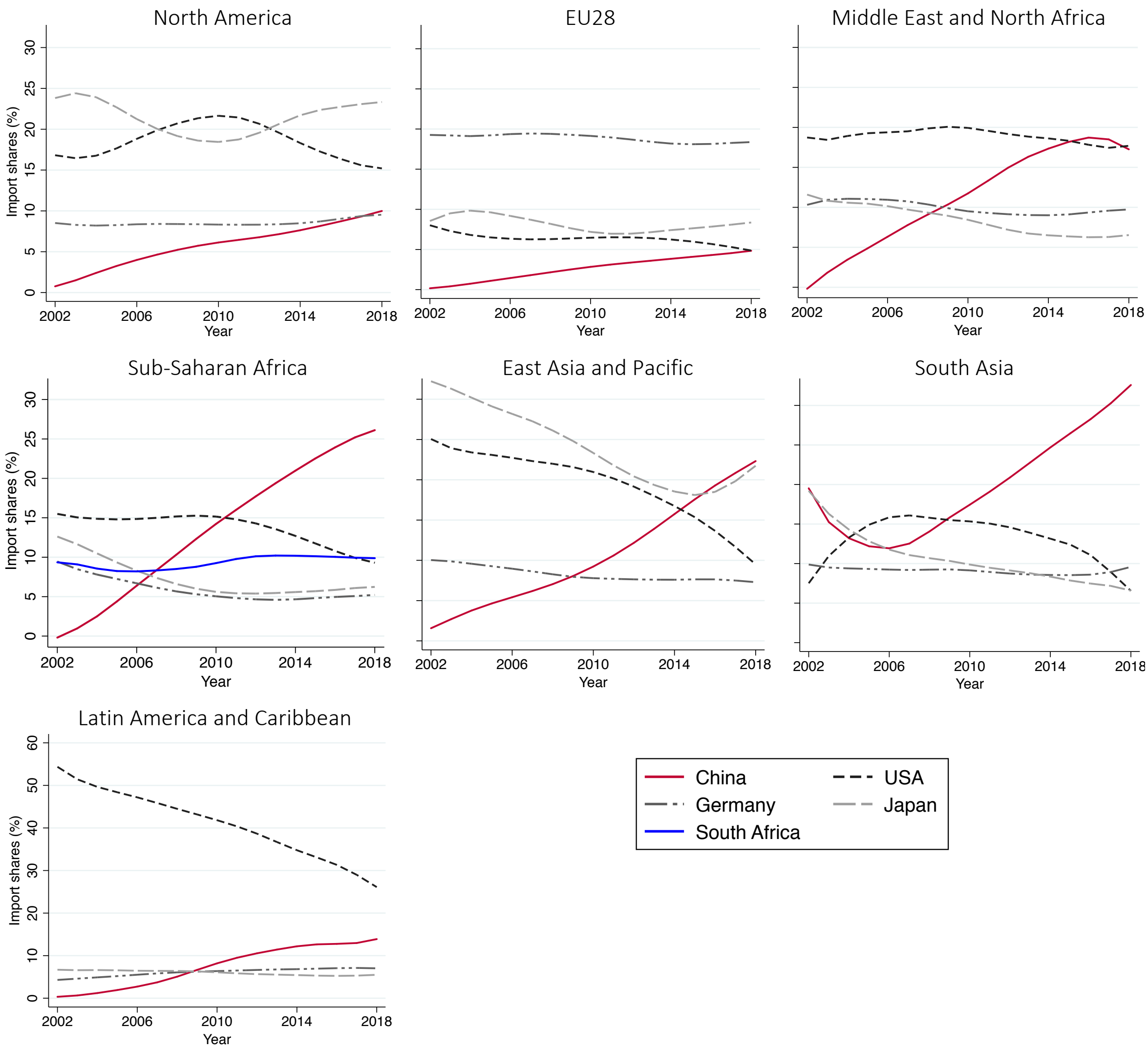
Source: Own elaboration based on UN Comtrade data (UNCTAD, 2020).

Figure 5.7 compares the regional shares in total imports of mining equipment over the 2002-2018 period for the top four world exporters (China, USA, Japan and Germany).[148] Consistently with the focus of this chapter, and as a major regional player in mining equipment exports, South Africa is included in the analysis for sub-Saharan Africa. The graphs show that China's shares in total imports of mining equipment have risen across all world regions during

[147] Data on mining equipment output for major producers is derived from a variety of sources (METI, 2020; Eurostat, 2020; UNIDO; 2020; NBS, 2017; Farooki, 2012).
[148] See Figure C.3.1 in Appendix C for trends in China's share and the shares of its main competitors in total world imports of mining equipment over the same period.

the period analysed, while its main competitors have experienced stagnant or declining shares in total imports across the different regional blocks.

Figure 5.7. China's shares in total mining equipment imports, selected regions (2002–2018).



Source: Own elaboration based on UN Comtrade data (UNCTAD, 2020).

Over the last two decades, China has also experienced a huge increase in its mining equipment imports, fuelled by the surge in investments in domestic extractive operations. In 2018, with USD 4.3 billion of mining equipment shipped from abroad (7.8% of global imports), the country was the fourth major world importer, after the USA (USD 16.1 billion), Canada (USD 6.8 billion) and Germany (USD 5.6). Combined with export figures, import data reveals that in 2018 China achieved a large trade surplus of USD 11.8 billion, up from a small deficit of USD 86.4 million in 2010.

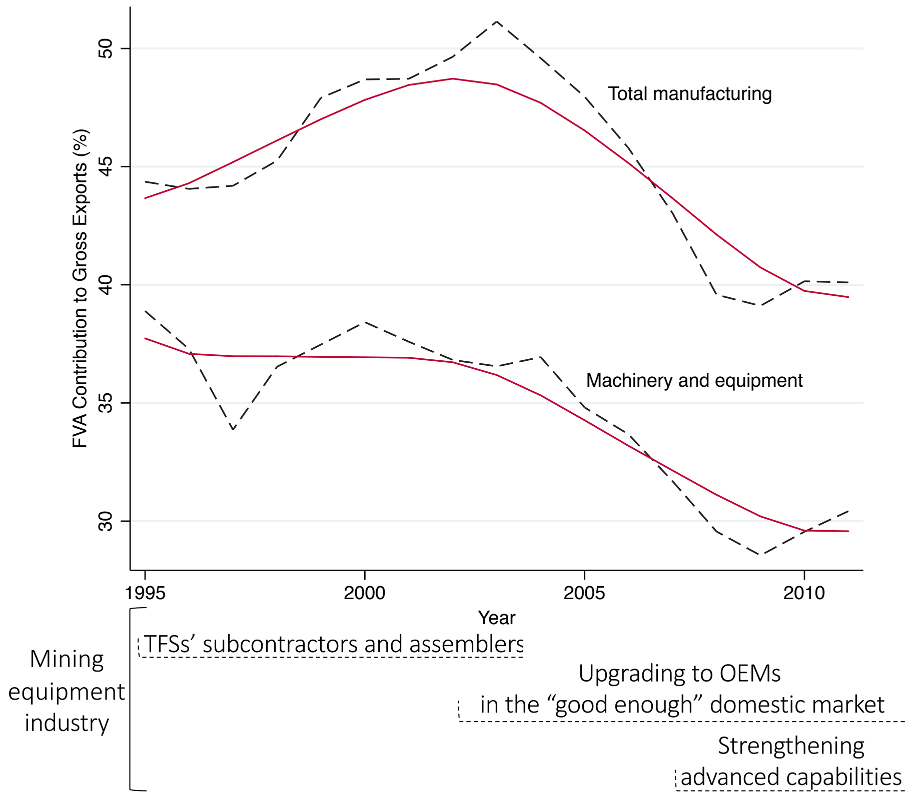
However, in light of the growing importance of GVCs over the last three decades, a country's trade surplus might be lower when measured in value added terms rather than in gross terms (Koopman et al., 2014). So, the remarkable export performance of China in the mining equipment sector reviewed above should not be interpreted as evidence per se that Chinese firms are able to compete globally with established producers from advanced countries. In fact, it might be the case that the bulk of mining equipment exported by China is not manufactured by domestic firms, but by TFSs using Chinese companies as component assemblers and export platforms within GVCs.

Admittedly, this was probably the case until the early 2000s. However, during the last two decades, China has upgraded its position within GVCs towards higher value added and more skill-intensive activities in many industries (Tassey, 2014; Zhou et al., 2016; Lee et al., 2018). A recent article by Lee et al. (2018) shows how the trends of GVC participation and local knowledge creation in China over the past decades tend to be consistent with an 'in-out-in-again' upgrading pattern. The article reports that China's foreign value added (FVA) in gross exports (equivalent to its backwards participation in GVCs) grew until 2003. Then, it started to decrease with the country's attempt to strengthen domestic productive and technological capabilities, and create more local value added, relying less on foreign-dominated GVCs. According to trade in value added (TVA) data used in this chapter, this decline is still ongoing,[149] thereby tracing an 'in-out' pattern.

Lee et al. (2018) predicted that China's share of FVA in gross exports would increase again in the near future, with the reintegration into higher value added stages of GVCs and with the establishment of its own GVCs. In Figure 5.8 this 'in-out' upgrading pattern is reported for China's manufacturing industry, and machinery and equipment sector between 1995 and 2011.[150] TVA data on machinery and equipment sub-categories are not available, so this is used as a proxy for the dynamics of China's participation into mining equipment GVCs.

[149] The analysis by Lee et al. (2018) is based on TVA data from 1995 to 2011 (OECD-TiVA, 2016).
[150] Figure 5.8 builds on the 2016 release of the OECD-TiVA database, as in Lee et al. (2018). Figure C.3.2 in Appendix C also includes data from the 2018 release and the trends show that the 'out phase' of increasing domestic value-added share is still ongoing.

Figure 5.8. The 'in-out' industrialisation pattern in China: manufacturing, and machinery and equipment.



Notes: in red LOWESS-smoothed values.
Source: Own elaboration based on trade in value added data (OECD-TiVA, 2016).

Taking Figure 5.8 as a starting point, the following sub-sections aim to explore the dynamics of China's participation and upgrading along the mining equipment GVC further. According to information gathered from own interviews with industry experts, emerging Chinese OEMs are becoming increasingly competitive on a global scale in specific sub-segments of the surface mining equipment market and the mineral processing market (Interviews 012398, 025392 and 062001). As a result, to trace the upgrading dynamics of the Chinese mining equipment sector, in what follows I specifically make reference to these product segments. The development trajectory of the Chinese construction equipment industry is included in the analysis, given the fact that the line between open-cut mining, and heavy construction and earthmoving equipment, is extremely blurred for a number of product ranges (Interviews 012398 and 062001; Brandt and Thun, 2010, p. 1565, Figure 5.8).

On the basis of own interviews and a careful analysis of secondary sources, three key phases of this upgrading process have been identified, consistent with the 'in-out' pattern outlined in Figure 5.8. Chinese suppliers have initially entered traditional MGVCs led by foreign GDMCs by manufacturing less strategic components for high-end equipment produced by large TFSs

(Bamber et al., 2016). Then, since the mid-2000s, taking advantage of the huge and segmented domestic demand for heavy industrial equipment, many Chinese producers emerged outside traditional MGVCs. Actively supported by government, they managed to achieve success in the domestic low-end market and to rapidly upgrade into original equipment manufacturing for the booming mid-segments, whether under collaboration with TFSs or not. Finally, after 2008,[151] many of these OEMs started to internationalise in both advanced and emerging economies. This internationalisation process has been built upon the gradual accumulation of some selected advanced investment, linkages and end-market development and service capabilities, and largely supported by the 'going out' strategy of many large Chinese investors and contractors.

5.5.2.2 Entry in high-end MGVCs as TFSs' subcontractors

Over the past three decades, a number of Chinese firms have been able to integrate into mining equipment GVCs as suppliers of leading TFSs by developing the basic subcontractor capabilities reported in the first row of Table 5.3. Many TFSs, indeed, have expanded in the Chinese market, attracted by large pools of low-cost labour, efficient manufacturers with rapidly growing productive capabilities, abundant raw materials, and a sizeable and booming domestic market for construction- and mining-related technologies. In the mid-1990s, they gained local presence primarily by partnering with domestic suppliers, and opening manufacturing and assembling plants through wholly owned foreign enterprises (WOFEs) and production JVs.

Sandvik, Caterpillar and Komatsu started to produce less strategic components and to assemble machines in China between 1994 and 1995. In the early 2000s mineral processing TFSs like FLSmidth and Metso also opened their first manufacturing facilities in the country. In many instances, as the capabilities of their local suppliers and facilities have grown and improved, lead TFSs have started to integrate them into their global supply chains for world class and premium equipment, substituting their traditional suppliers (Interview 025390).[152]

However, traditional GDMCs, in addition to leading TFSs, have also played an important role in facilitating the entry of Chinese companies into the mining equipment GVC, especially

151 2008 is taken as a turning point since in this year the Chinese policy focus started to shift from the creation of a group of national champions to international competitiveness, expansion of foreign market share and independent innovation capacity. See Section C.3.4 in Appendix C for further details on this.

152 Core parts for surface and underground mining vehicles such as hydraulics, electronic control systems and engines continued to be sourced from key global suppliers. However, the buckets of excavators have been outsourced to Chinese manufacturers (Interview 025567).

during the mining super-cycle. Indeed, given the limited capacity of some of their incumbent manufacturers, many mining majors began to purchase less critical and complex equipment and components from Chinese providers with large-scale capacities and strong re-engineering capabilities to meet project deadlines (Interview 042347; Bamber et al., 2016).

5.5.2.3 Upgrading to OEMs in the 'good enough' domestic market

Since the mid-2000s, the fastest growth rates in the Chinese construction and mining equipment sector have been registered in the middle segments of the market (Brandt and Thun, 2010).[153] This growth have been primarily fuelled by the commodity super-cycle and the shift in the customer base of the mining industry towards China and other emerging Asian economies (Humphreys, 2015 and 2019). Moreover, the increasing volumes of the middle segments in the broader Chinese heavy equipment industry have been also driven by the unprecedented domestic construction boom since 2005, which was further reinforced by the massive government fiscal stimulus package in 2008. The dynamics of competition among TFSs and local producers for the domestic middle segments of the market have deepened the capability building and local value-addition in the Chinese construction and mining equipment industry. Many local companies have been able to build those sectoral GVC-specific capabilities reported in the second row of Table 5.3 necessary to upgrade into original equipment manufacturing.

On the one hand, this fight for the booming 'good enough' market segment (Gadiesh et al., 2007) has provided TFSs with strong incentives for lowering costs. This has been achieved through the localisation of sourcing and design activities through WOFEs and JVs (Interview 025392). In particular, starting from the 2010s, there has been a new wave of M&A and JVs conducted by TFSs, aimed at creating mid-price brands alongside their premium and world class product lines, and producing core components for the mid-market segments (Interview 025392).[154] Mid-range machines have been initially designed and produced for the Chinese mid-market segments but, over time, have also been exported to other emerging economies.

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153 The relevance of the mid-market segments of the Chinese mining equipment industry is both country- and sector-specific. First, the large size of the 'good enough' market has to do, more generally, with the huge size and growth rates of domestic demand in China. Second, the high importance of the mid-market segment is typical of industry markets like machinery and equipment, characterised by long-cycle technologies. In other sectors with short-cycle technologies the 'good enough' market segments are more rapidly eroded (Lee, 2019; Rugman and Nguyen, 2014).

154 Table C.3.1 in Appendix C reports a list of selected M&A and JVs conducted by TFSs with Chinese mining equipment and consumables manufacturers.

These products have proved to be particularly attractive for tier-3 miners with limited access to funding and few operations, often characterised by relatively short time horizons.

On the other hand, the competition with TFSs for the domestic middle-market has also enhanced the upgrading prospects for a number of Chinese firms. This has been achieved through different channels. First, a key part of the upgrading process has been the strategic use of JVs with TFSs to develop key competences and to expand capabilities in product design, production organisation and end-market development and service (Interview 035203). Related to this, the flow of well-trained personnel from foreign subsidiaries and JVs to domestic firms has also been an explicit upgrading channel (Interview 035203 and 035123). Furthermore, the most successful domestic firms have been able to upgrade on the back of pre-existing capabilities within the Chinese economy. In particular, current and former SOEs, such as LiuGong, XCMG and CITIC Heavy Industries, with their extensive experience in product design and strong engineering capabilities, have been able to make continuous incremental improvements over time in product quality (Interview 035132). They have played a critical role in the upgrading of the entire Chinese construction and mining equipment ecosystem, including private sector firms that have strongly relied on the resources and expertise of the state sector to grow (Brandt and Thun, 2010 and 2016). Finally, these emerging OEMs could rely on their capabilities for solid linkages in terms of their strong domestic supplier base, their tight relations with specialised training and technology institutes, and their easy access to working capital finance and state support institutions.

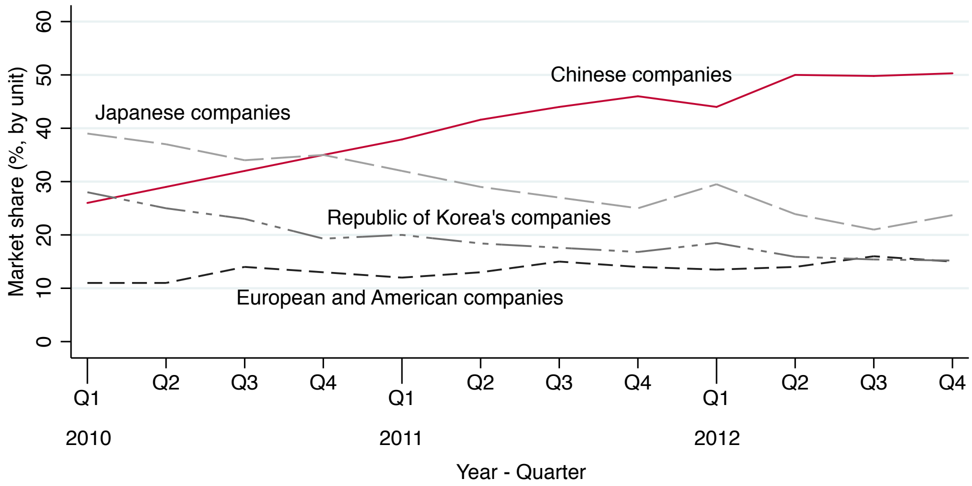
In particular on this last point, the Chinese heavy machinery industry has received strong governmental support through a number of national and provincial strategic plans published between 2006 and 2016 (Pepermans, 2019).[155] The upgrading of Chinese subcontractors into OEMs has been actively encouraged by government ministries, which have favoured the accumulation of the necessary firm-level capabilities. Combined with the large size of the domestic mid-market, this has also served as a source of strong bargaining power when dealing with TFSs for technology licencing, and the effective transfer of knowledge and competences (Lee, 2019, Chapter 5, pp. 327-333).

A striking example of the upgrading trajectory of Chinese firms is provided by the case of the yellow metals sector, traditionally dominated by TFSs headquartered in advanced economies. Prior to the global financial crisis, foreign-branded excavators accounted for a combined 90%

[155] The key policy initiatives in the sector are briefly reviewed in Section C.3.4 of Appendix C.

market share (CLSA, 2013; Poon, 2014). After 2008, domestic demand for this type of equipment increased considerably on the back of the spectacular recovery of the Chinese economy, driven by the government's economic and fiscal stimulus package of 2008-2009. The subsequent construction boom led to an increase in the procurement of construction machinery from Chinese OEMs like Sany, Zoomlion and LiuGong. While these Chinese companies still lagged behind foreign firms in terms of many sectoral GVC-specific capabilities, they were able to offer their clients a standard portfolio of machines of reasonable quality at extremely competitive prices and by 2012 their excavators accounted for over 50% of the domestic market (see Figure 5.9).

Figure 5.9. China's domestic excavator market share trends, by quarter, 2010–2012.



Notes: European and American companies include Caterpillar, Volvo, Liebherr, Atlas Copco; Chinese companies include Sany, Yuchai, LiuGong, Strong, SDLG, Lovol, Xiamen XGMA, Sunward, Zoomlion, Lishide, Shandong Carter, Rongsheng, Guangxi Kaiyuan, Jonyang Kinetics, Pengpu; Japanese companies include Komatsu, Hitachi, Kobelco, Sumitomo, Yamaha; Republic of Korea companies include Doosan, Hyundai-Beijing, Hyundai-Jiangsu. Source: China Construction Machinery Industry Association, 2013.

This domestic demand-led growth for Chinese-branded heavy construction and earthmoving machines has been the basis for the lateral migration of these companies into the market for open-cast mining equipment (e.g., large tonnage excavators, wheel loaders and dump trucks), fuelled by the commodity boom and the development of the Chinese overseas mining industry (Interview 062001).

5.5.2.4 Building up and integrating a set of more advanced sectoral GVC-specific capabilities

After 2008, many of these OEMs started to internationalise in both emerging and advanced economies. These strategies of expanding into foreign markets have been built upon the gradual accumulation of some selected advanced investment, linkages and end-market development and service capabilities.

a. The South-South strategy: from export to FDI and the role of downstream Chinese investments

Having achieved a strong position in their domestic market, Chinese OEMs started to export to important emerging markets in Africa, Asia and Latin America (see Figure 5.7). Many producers of open-cast mining machines have intensively invested in overseas offices to be able to effectively perform after-sales activities: over time they have established distributed dealer networks, sales subsidiaries, local parts warehouses or partnerships with local service providers in a number of strategic host countries such as South Africa, Brazil, Chile and India (Interviews 035132 and 035203).[156]

Between 2008 and 2015, after the initial learning from this export-based internationalisation process, a number of companies, such as Sany, LiuGong, XCMG and Zoomlion, also invested in complementary resources, such as local manufacturing facilities and R&D centres in the two largest emerging markets for heavy earthmoving equipment, India and Brazil (Interview 035132). Furthermore, many Chinese OEMs are currently in the position of being able to provide their clients with favourable equipment financing options, often backed by public financial support. These equipment selling models are tailored to the specific needs of tier-3 mining firms and include leasing agreements with payment on a per-hour or per-ton basis (Interviews 025391 and 035203).[157]

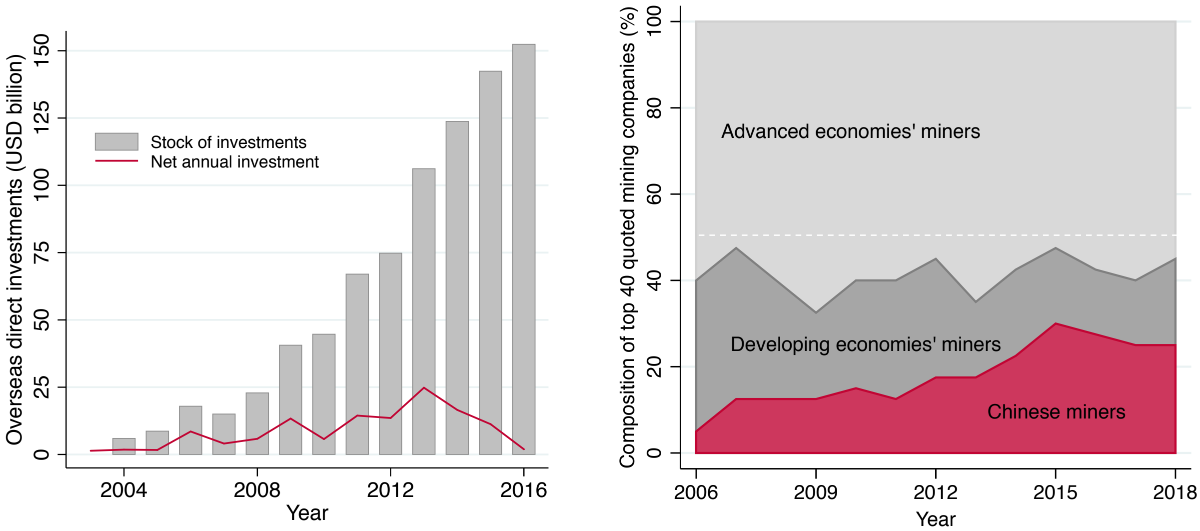
A major catalyst for the expansion of Chinese mining and construction equipment manufacturers in other mining markets is represented by the rising overseas direct investments (ODI) of their domestic customers, namely mining companies and construction contractors. According to official Chinese data sources, by 2016 China had become the world's third largest

[156] The open-cast mining machines market is characterised by relatively weaker regimes of appropriability and a more established technological paradigm with respect to other mining technologies. Therefore, on the one hand it constitutes an easier entry point for new competitors, but on the other hand, within this segment, the control over specialised complementary resources (e.g., a global network of after-sales support centres) and the ability to offer competitive equipment finance packages are of primary importance for effectively capturing value from upgrading efforts (Sako and Zylberberg, 2019; Interview 025567).

[157] Pumps, for example, can be sold on an hourly basis: this means that for every hour that the pump is in service the customer would pay a certain amount. For mobile crushing stations, payment can be based on the throughput: thus, for every ton of material that goes in, the customer would pay a certain amount. Simple counters mounted on the equipment can easily control for these metrics. These types of funding scheme can provide relatively smaller miners with significant flexibility and with the possibility of proving to potential shareholders their ability to service debt (Interview 025391).

mining investor, after the UK (USD 203 billion) and the USA (USD 170 billion),[158] accumulating over USD 152 billion of foreign mining assets (NBS, 2017). This equated to 11% of China's total stock of foreign assets. Figure 5.10a shows net foreign direct investment mining rising from USD 1.6 billion a year over 2003–2005 to an annual rate of USD 16.0 billion in 2011–2015. This suggests that net overseas investments in mining have, in recent , accounted for around 15% of total Chinese net FDI. Over this time period, Chinese investors, mostly consisting of SOEs, have played a growing role in the global mining industry. As shown by Figure 5.10b, by 2015 they had risen to account for over a quarter of the top 40 mining companies.

Figure 5.10. China's mining ODI, 2003-2016 (a) and composition of top 40 mining companies, 2006-2018 (b).



Source: Own elaboration, (a) based on NBS (various years), (b) based on PwC (various years).

An emerging empirical literature focusing specifically on sub-Saharan African countries indicates the distinctiveness of the investments of Chinese SOEs into the resource-sector and related infrastructure that was historically dominated by firms from advanced economies (Kaplinsky and Morris, 2009). According to interviews conducted with industry representatives and experts, Chinese investors in sub-Saharan Africa tend to govern value chains that are relatively more vertically integrated or at least hierarchical. As a result, subcontracting, and sourcing of capital equipment and consumables, seem to be largely circumscribed to Chinese project houses and suppliers (Interviews 025391, 057801, 041099 and 042347). This finding is in line with a number of previous empirical contributions (Henderson and Nadvi, 2011;

[158] Data for the UK and the USA are provided by OECD (2020), Outward FDI stocks by industry (indicator). DOI: 10.1787/db70d1c4-en.

Ferreira, 2009; Brautigam, 2009 and 2011; Tull, 2006; Zeng and Williamson, 2007; Fessehaie 2012a; Fessehaie and Morris, 2013).

b. The South-North strategy: entering advanced markets through M&A as a springboard to catch-up

As Figure 5.7 indicates, Chinese import shares in North America and Europe are much lower than in other regions. This provides evidence of the fact that Chinese equipment manufacturers have so far found it difficult to enter these advanced high-end markets through a purely export-based internationalisation strategy. Furthermore, in the medium to long run, the entry of TFSs into Chinese mid-market segments will also put them under pressure in their domestic market. Thus, the acquisition of more sophisticated products and the exposure to advanced markets became a strategic necessity for many of these companies (Interviews 035132, 035203 and 025392).

Through several strategic M&A, greenfield investments and JVs, often backed by public financial support, Chinese OEMs have started to build positions into advanced markets, with the aim of acquiring resources and building advanced capabilities to narrow down the technology and quality gap with major TFSs (Bruche and Hong, 2016; Pepermans, 2019). Two cases in point are the acquisitions between 2011 and 2012 of the Spain-based mining equipment manufacturer Gandara Censa, and of the Poland-based manufacturer of heavy earthmoving equipment and open-cast mining machines Dressta, by CITIC Heavy Industries and LiuGong, respectively (Interviews 035132 and 025392).

5.5.2.5 Implications for chain polarity and horizontal competition along MGVCs

Chinese firms have followed an upgrading path in three phases. First, they have integrated into traditional MGVCs led by foreign GDMCs as subcontractors. Then, they have managed to rapidly upgrade into original equipment manufacturing for the booming domestic mid-segments, whether in collaboration with TFSs or not. Finally, while they are still not able to develop and commercialise bespoke integrated solutions, some of these OEMs have successfully expanded into foreign markets, strengthening and integrating a set of advanced capabilities and key complementary resources to effectively perform after-sales services, offer competitive vendor financing deals, conduct M&A, and establish strategic partnerships in both advanced and emerging countries.

Through this capabilities accumulation process, supported by active and targeted government policies and by the large size of the domestic market, many Chinese companies have been able to participate and upgrade along multiple value chains (Horner and Nadvi, 2018), from domestic to foreign-led, and from locally oriented to regional and global ones.

In particular, in the case of non-Chinese-led MGVCs they have contributed to re-mould chain polarity and horizontal competition dynamics. Through their ability to produce on a very large scale and to provide their clients with extremely competitive vendor financing solutions they have managed to become certified and preferred suppliers for many tier-3 mining firms (Interview 025391), but also for a number of global project houses and GDMCs, such as BHP Billiton, Codelco, Rio Tinto, Glencore and Anglo American (Interviews 035132 and 035203).[159] At the same time, the upgrading of Chinese OEMs is also exerting substantial competitive pressure on other first-tier suppliers, from both advanced and emerging economies. This, in turn, might force other first-tier suppliers to adjust to the new competitive landscape through a mix of strategic initiatives, including technology partnerships, adaptive downgrading and specialisation in complementary tasks.

5.6 Capabilities, upgrading and value capture challenges: a case study on selected South African OEMs

Having examined the reorganisation trajectories taking place within the global mining equipment sector in the last two decades, I now move on to analyse the specific case of the South African mining equipment industry. Sections 5.6.1 to 5.6.5 address RQ3, RQ4 and RQ5. First, I describe the patterns and the quality of interactions prevailing within the South African mining equipment value chain among key actors, analysing how this power configuration affects upgrading efforts by local suppliers (Section 5.6.2). In doing so, I focus on both the GVC governance patterns involving mining companies, project houses and immediate suppliers, and the rivalry dynamics between local first-tier suppliers, TFSs and emerging Chinese OEMs. Second, through selected firm case studies I explore the nature of the upgrading trajectories of the local suppliers in the sample and their key capabilities (Section 5.6.3). Third, I look at the internal and external factors that limit their agency and their transition towards high-value integrated solution providers (Section 5.6.4). This is preceded by

[159] As an example, CITIC Heavy Industries is currently one of the three companies in the world that is able to supply a 40-feet in diameter grinding mill and it is among the preferred suppliers of steel grinding media and ball mills of many global EPCM companies operating in Southern Africa (Interviews 025392, 057801 and 057802).

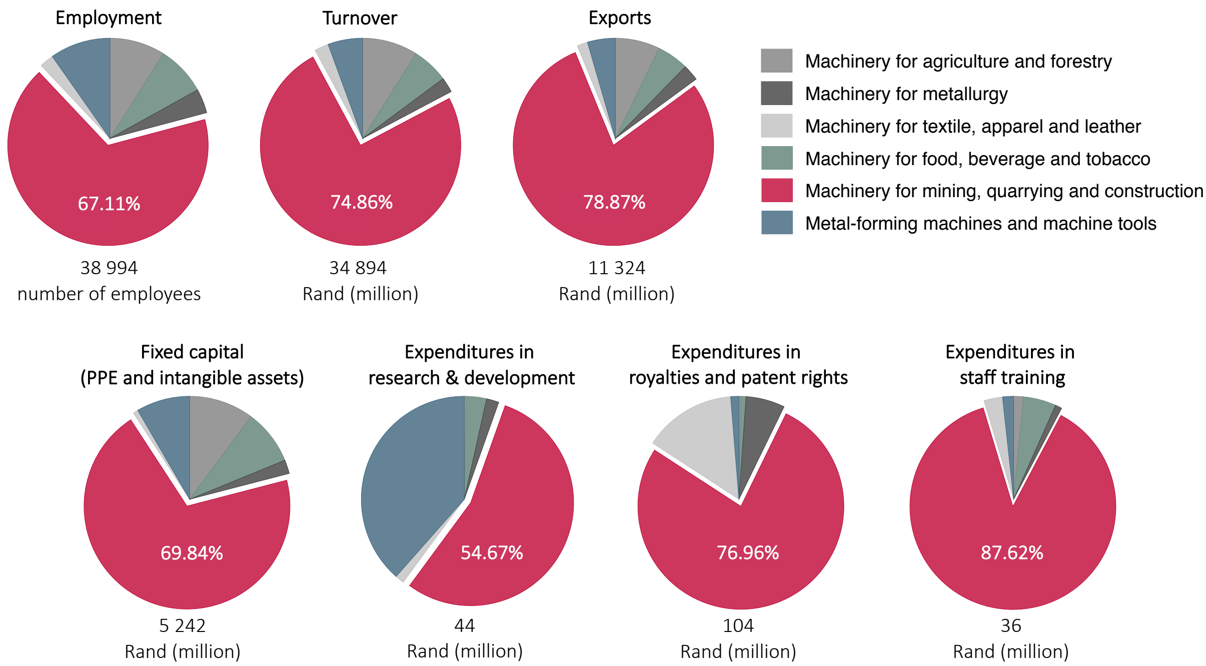
an overview of the sector in South Africa (Section 5.6.1), and followed by a discussion on the main findings and related policy implications (Section 5.6.5).

5.6.1 The South African mining equipment industry: a brief overview

The mining equipment sector represents the most relevant and technologically advanced segment of the South African special purpose machinery industry (Kaplan, 2012; Lyndall, 2009; Walker and Minnitt, 2006). As shown in Figure 5.11, in 2017, South Africa-based mining equipment companies contributed to more than 67% of the total employment in the special purpose machinery sector, and to 75% and 79% of its total turnover and exports, respectively.

The development of a mining equipment ecosystem in the Gauteng province – two-thirds of the employment and turnover are concentrated there – has driven processes of technological capabilities development and diffusion. Indeed, this sub-sector also makes a hefty contribution to the total non-current assets (70%) and spending in capabilities development undertaken in the specialised machinery industry, as proxied by expenditures in R&D (55%), staff training (88%), and royalties and patent rights (77%).[160]

Figure 5.11. Relevance of the mining equipment sector in South African specialised machinery industry, 2017.



Source: Own elaboration, based on SARS (2019), AFS (2018).

[160] Further indications of the technological sophistication of the sub-sector are the quantity and quality of mining-related technology patents (Kaplan, 2012).

The proximity to the mines, the demand for customised solutions well-suited for the specific local geological conditions, and the strong national mining innovation system between the late 1970s and late 1980s in particular, have been critical drivers of learning for locally owned companies (Interviews 017703 and 019079; Kaplan, 2012; Pogue, 2006). However, although a number of these firms are large by local standards, they are still significantly smaller than the leading multinationals operating in South Africa, and their expertise and competencies are particularly advanced and at the global frontier only in specific product segments. In what follows, an overall picture of the South African mining equipment sector is provided mainly through four key aspects: nationality of ownership, company size distribution, main areas of technological expertise, and the nature of business models and key activities.

5.6.1.1 Ownership pattern

Over the years, the sector has attracted significant FDI by leading TFSs, which selected the country as a preferred location in which to undertake distribution and sales activities and, to a much lesser extent, also R&D (Interviews 025793, 025876 and 025572). More recently, a number of emerging Chinese OEMs have invested in warehouse facilities in the country, to be used mainly as gateways to enter other sub-Saharan markets (Interviews 035132 and 035203). In 2018, 34% of the companies in this sector were foreign, accounting for 46% of the industry's turnover (WOW, 2019). These global firms include subsidiaries of TFSs and Chinese OEMs, and specialised project houses. Local companies include suppliers at any tier along the chain (Interviews 019079 and 012398).

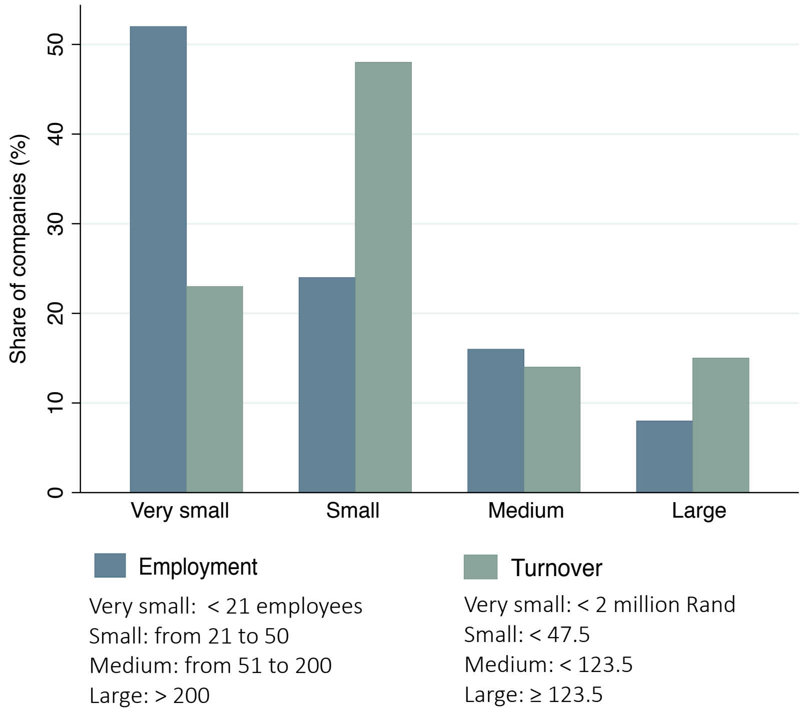
5.6.1.2 Size distribution

As shown in Figure 5.12, in 2017 the mining equipment cluster was mainly composed of small companies (76%), while medium and large companies accounted for 16% and 8%, respectively. In terms of turnover, 71% of companies were classified as small, 14% as medium and 15% as large. Medium and large firms, regardless of the specific classification used, account for the bulk of total employment, sales, exports and investments.[161] Key foreign TFSs operating in South Africa are generally large companies, while sales subsidiaries of Chinese OEMs are mainly small ones. Local OEMs fall into the small and medium-size classes, with some notable exceptions like Bell Equipment, Multotec and Master Drilling. Because of their limited size, these local companies face serious constraints in terms of scale of production, as well as

[161] In 2014, the top ten largest enterprises by turnover contributed over 52% of the total sectoral income (AFS, 2014).

organisational and financial capacity, especially during the phase of commercialisation of their innovative products.

Figure 5.12. Size distribution of mining equipment manufacturers in 2017, by employment and turnover.



Source: Own elaboration, based on SARS (2019) using firm size classifications provided by the DTI (2016).

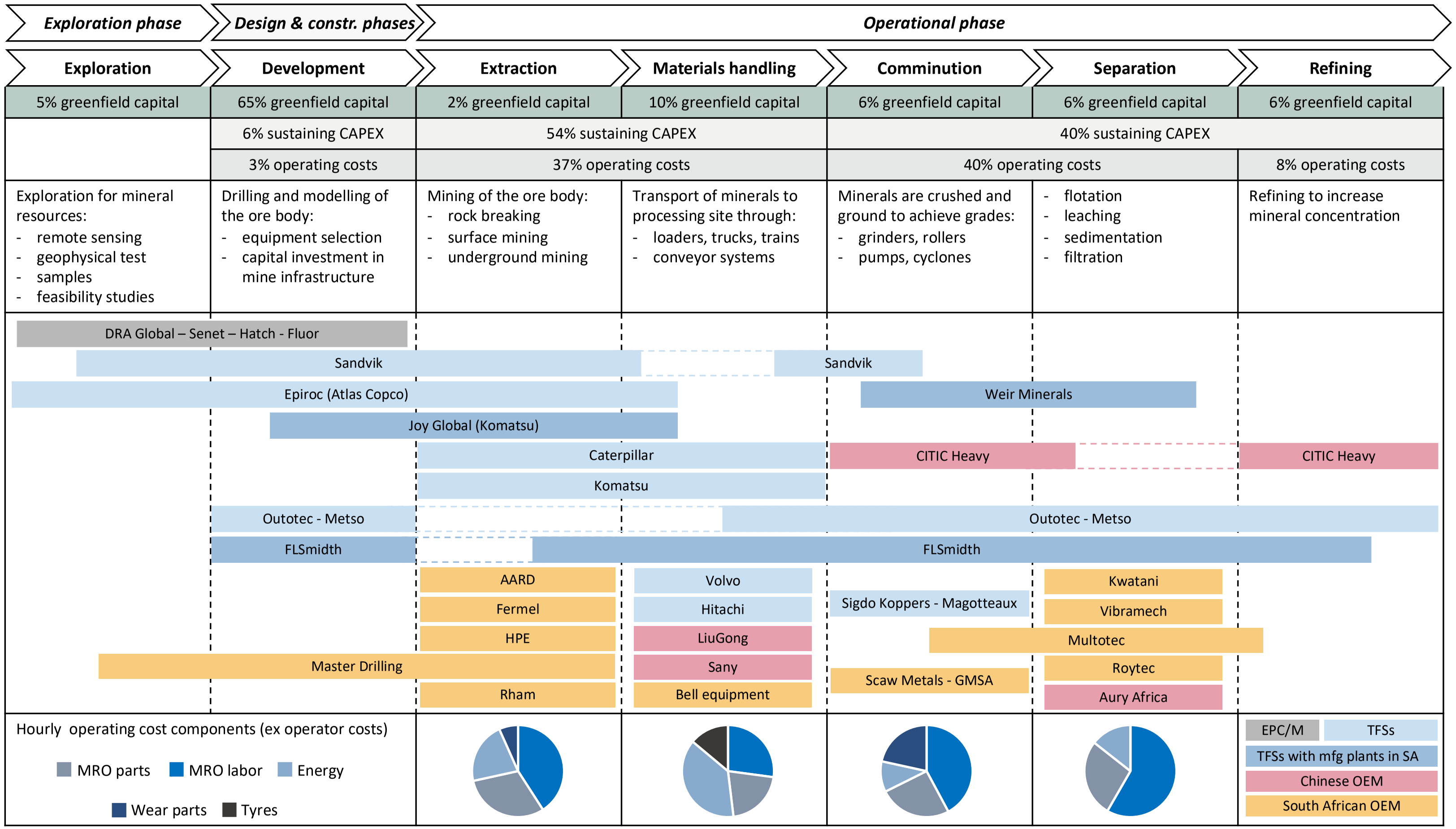
5.6.1.3 Main areas of technological expertise

Locally owned companies have particularly strong capabilities in developing and offering products and services in certain fields, such as deep level mining and related areas, where customised and niche solutions well-suited to the specific geological conditions of South Africa can provide substantial added value for the end-client (Interviews 019078, 014367 and 062003). These machines include spirals for washing coal, vibrating equipment for mineral processing, mining pumps for deep level mines, hydropower equipment, tracked mining equipment, underground locomotives, ventilation equipment and drilling solutions (Kaplan, 2012). However, for those products whose global success is strictly linked to large economies of scale and standardisation, the competitive position of South African companies is much weaker (Interview 019079).

5.6.1.4 Business models and main activities

Local OEMs undertake R&D and system integration activities in-house, often outsourcing some fabrication stages to local suppliers and importing components not available locally. They are directly involved in after-sales support activities, such as maintenance and repair, refurbishment and operator training (Interviews 019079, 012398, 014367). Foreign companies have established a much more varied range of business models to operate in South Africa and in the broader region. The majority of them exclusively undertake distribution and after-sales activities through an extensive network of local and regional branches (Interviews 025132 and 035132). Some of them also offer customisation services and outsource the fabrication of a few non-core components to local suppliers (Interviews 025567 and 025876). A small number of TFSs have set up local plants, where they fabricate and assemble selected product lines, nurturing and supporting a number of local suppliers (Interviews 025572 and 025390). For some of these locally manufactured machines, multinationals' subsidiaries also undertake R&D in-house (Interview 025793). No single subsidiary of a Chinese OEM undertakes substantial manufacturing activities locally (Interview 035203). Figure 5.13 shows the most relevant firms – local, TFSs and Chinese OEMs – operating in the South African mining equipment sector.

Figure 5.13. Key mining machinery manufacturers operating in South Africa



Source: Adapted from Zalk (2017), based on own interviews.

5.6.2 Patterns of interaction in the South African mining equipment value chain

5.6.2.1 Main entry barriers for local suppliers in regional and domestic mining projects

Notwithstanding the advanced core technological capabilities of many South African OEMs, a large proportion of mining equipment and machines used in local and regional mining projects is sourced from foreign companies with no (or only limited) manufacturing and engineering footprints in South Africa. Local suppliers face significant barriers when dealing with both international (i.e., regional) and domestic mining projects.

a. Horizontal competition and main entry barriers in the regional market

Through a long process of internationalisation, further reinforced from the mid-1990s by the ongoing decline in domestic ore production, many South African mining houses became truly globalised multinationals with worldwide operations (Robinson, 2016). In particular, over the last two decades, the focus of many major mining companies has shifted towards other Southern African countries (Interview 057802), like Botswana (diamonds), Zimbabwe (platinum group metals), Zambia (copper), Namibia (uranium) and the DRC (copper, cobalt) that have also increasingly attracted investments by emerging Chinese miners (Fessehaie, 2012a; Humphreys, 2015; Wegenast et al., 2019).[162] As already mentioned, the internationalisation strategies of traditional end-clients have benefitted large TFSs which have the capabilities, complementary resources and reputation to handle large-scale projects in different and remote locations.

Moreover, the growing presence of Chinese investors in the Southern African region, given the vertically integrated or hierarchical nature of these Chinese-governed value chains (Fessehaie, 2012a; Interviews 082956 and 089671), have also led to a strong increase in imports of mining equipment from China into these countries.[163] Such dynamics place South African OEMs in a difficult competitive situation when dealing with global and regional mining

[162] While still being the major miner in the Southern African Development Community (SADC), South African share of ore production in the region is declining. Between 2000 and 2013, its share of ore production in the region (excluding coal) declined from 66% to 56% (Jourdan, 2015). Also, more recently, the South African mining sector has been experiencing negligible levels of investments in new mining projects and greenfield exploration (Interview 025791).

[163] Both imports from China and Chinese market share have grown strongly between 2002-2018 in many of the main markets for South Africa for mining equipment. In 2018, Chinese market share for these products was extremely high in Zambia (54%), Tanzania (44%) and Angola (35%).

projects.[164] Overall, the internationalisation of the South African mining industry has not provided an effective gateway for local suppliers to enter new markets (Interviews 062189 and 057801).[165] Moreover, the increasing presence in the region of investors from other emerging economies has not yet contributed to widening their customer base (Interview 019079).

b. Horizontal competition and main entry barriers in the domestic market

For domestic projects, local suppliers face relatively lower barriers. In fact, the Mining Charter (DMR, 2018) establishes stringent local content requirements for the procurement of mining products and services.[166] However, although mining companies have made good progress in increasing their share of local procurement (DMR, 2015), a large proportion of mining equipment is still imported from abroad, even when sourced locally. According to own estimates, the South African mining equipment sector in 2018 faced a relatively high import penetration ratio (52%),[167] of which over one fifth was accounted for by imports from China. Other major origins of imported equipment are, in descending order, the USA, Japan, Germany, Sweden, the Republic of Korea and Finland.

It is a common opinion within the local private sector that the demanding local contents provisions of the Mining Charter create a number of unintended distortions and pockets of unproductive rents-capture for a small group of actors, further increasing barriers for competent local suppliers (Interview 014367). It has been observed that in some instances the procurement of inputs by mining houses has shifted from those that are locally produced (possibly by local manufactures which, however, do not qualify as historically disadvantaged with respect to their ownership) to imports that have been purchased abroad by local traders and distributors which qualify as historically disadvantaged (Interviews 014367 and 019113). This points to the weaknesses of the monitoring and verification mechanism of local content requirements and to the strikingly low maturity of the supply chain management practices of

[164] The econometric results in Chapter 4 reveal that, after the global financial crisis, Chinese exports of mining equipment and machinery products in third markets have crowded out South African exports in the same product categories and destination countries. This effect is particularly severe for products directed to other sub-Saharan markets.

[165] On the contrary, the transfer of Anglo American's head office and primary listing to London in the late 1990s and the demise of the domestic engineering assets of Anglo American Industrial Corporation, its primary industrial subsidiary, have deprived the South African economy in general, and its mining input cluster in particular, of massive technical and financial capacity (Robinson, 2016; Zalk, 2017).

[166] Table C.4.1 in Appendix C traces changes over time of the procurement-related provisions contained in the Mining Charter.

[167] Up from 45% in 2010 (Quantec, 2020; AFS, 2010 and 2018).

mining companies, especially with respect to the use of standardised product identification coding systems (Interviews 062189 and 081013).[168]

5.6.2.2 The dynamics of governance and chain polarity in multiple MGVCs

Despite these barriers, a considerable number of specialised South African mining suppliers have been able to integrate into multiple MGVCs governed by different types of mining companies. Still, my interviews revealed that these suppliers find it difficult to engage in functional relationships with lead actors, in spite of their advanced technological capabilities.

a. Value chains with major mining companies

In the South African mining sector, large mining companies dominate the value chain. While representing less than 7% of total companies, in 2018 the majors accounted for over 92% of total industry revenue and operational expenditures, and for almost 96% of capital expenditures (MCSA, 2019). They include both GDMCs and more domestically oriented South African mid-tier miners. These value chains represent the end-market with the highest growth and value capture potential from the point of view of equipment manufacturers (Interview 062001). As detailed in Section 5.5.1, the pre-existing relations between many of them and a limited number of entrusted TFSs often lead to the formation of truly global alliances to manage and execute large mining projects.

By contrast, the establishment of technology partnerships and JVs between major mining houses and local OEMs is an exception in the industry. According to my interviews, this relates to the major mining houses' current low-risk appetite, excessive short-termism and conservative attitude towards the development and adoption of new technologies. They generally favour an approach that shifts the costs of developing new solutions onto the shoulders of the OEMs, some of which (mainly local ones) are too small to bear those risks, and to offer new marketable and scalable technologies to their clients (Interview 019078, 014367). In this respect, the gradual demise of the Chamber of Mines Research Organisation (COMRO) from the early 1990s onwards has deprived South African OEMs of a strategic institutional leader and founder of mining research and technology, as well as a critical intermediary in their relations with large mining houses (Interviews 019078 and 019113; Pogue, 2006 and 2008).

[168] A recent procurement analysis has shown that about 40% of all mining companies' transactions in the South African gold and platinum group metals sectors, representing over the 65% of their total value, is 'unidentified' or 'free-text' (Smeiman, 2018).

A closer analysis of the relationships between local suppliers and their end-clients reveals that these are mainly asymmetrical, since local OEMs are smaller and less established than major mining companies. This asymmetry is further reinforced by the fact that major mining houses can choose from a relatively wide variety of potential suppliers, while local OEMs are strongly dependent on a handful of large end-clients. Following the traditional classification of GVC governance patterns (Gereffi et al., 2005), I consider the structure of the mining supply chain in South Africa involving major mining houses and local suppliers to resemble a captive value chain (Pietrobelli et al., 2018; Molina, 2018). Within this context, local OEMs face strong competition in terms of reputation and the offer of complementary services, mainly from large TFSs which are able to exercise more bargaining power with respect to major end-clients (Interviews 012398 and 014367). This is particularly the case for products like mineral processing plants and mining vehicles, including low-profile machines for underground operations, where scale economies and standardisation are critical.

In many instances, notwithstanding the widespread adoption of centralised procurement practices by many major mining companies (Interview 042347), local OEMs maintain strong and long-standing relations with certain project houses and their major clients at the executive and supervisor level of individual local mining sites (Interviews 017703 and 018345).[169] Especially for certain mining solutions and technologies tailored to the specific local geological conditions, the relationships between large mining companies and local suppliers are characterised by a higher degree of asset-specificity, which requires more exchange of information between the parties and a greater level of cooperation (Interviews 014367 and 19078).

However, within a context of stagnating mining investments in the country, local OEMs find it extremely difficult to introduce their innovations in regional and global markets, because of three reasons: first, the limited geographical scope of most domestic-oriented major South African miners makes it difficult for local suppliers to scale up and enter other markets (Interview 014367); second, the more globalised client base is extremely risk adverse and reluctant to adapt context-specific solutions to other worldwide operations (Interviews 019079 and 019113); third and related to the previous point, for large mining projects at the international level, global partnerships with lead TFSs tend to prevail (Interview 019078). Furthermore, for local OEMs, the possibility of increasing market presence abroad is

[169] In particular, for local projects, respondents reported a number of cases in which equipment has been co-designed by OEMs, project houses and large first-tier suppliers of critical consumables and components to meet the specific technical requirements of South African geological conditions.

constrained by their limited ability to set up support facilities for the equipment, ranging from fully equipped workshops to training hubs for engineers, operators, artisans and technicians, located in proximity to or even inside mining sites (Interviews 062001 and 062189).

b. The role of project houses in mineral processing value chains

Given the conservatism and reluctance to share risk characterising the procurement and investing choices of major mining companies, project houses can effectively provide a gateway for local suppliers, especially in the mineral processing space, to enter new markets. However, their current prevailing focus on EPCM rather than EPC projects[170] and their technology agnosticism prevent them from playing this key intermediation role. Large South African project houses do not have any strong preference over the origin of supplier ownership and maintain a substantial degree of flexibility to satisfy the end-client requirements, according to the specific project's conditions and location (Interview 057801).

Another issue reported by local OEMs is the excessive red tape and sheer technicalities characterising supply contracts between project houses and equipment suppliers (Interview 062189). Furthermore, non-disclosure agreements signed between mining companies and project houses often prevent local OEMs from engaging with mining houses at the early stages of projects development. These information asymmetries favour large TFSs that benefit from early access to mining projects (Interview 062765).

Project houses, in turn, underline the limited support offered by local suppliers, from both a risk and commercial point of view, especially when dealing with international mining projects (Interview 057802). Large TFSs with their significant balance sheets are able to offer both competitive financial packages through their in-house equipment finance and leasing organisations, and extensive after-sales services through their global networks of support centres. Moreover, as already discussed in Section 5.5.1, many mineral processing TFSs have started to offer specialised design and engineering services, acting as EPCM companies, but using proprietary equipment. Besides the increase in direct competition with project houses, this shift also strengthens competitive pressure on the local suppliers they select for tenders.

Project houses also report that a number of Chinese OEMs in the mineral processing segment have recently become certified and the preferred suppliers of major traditional companies for

[170] A major South African project house has estimated that 90% of its current projects are undertaken under EPCM contracts and it confirms that this is a broader tendency in the industry (Interview 057801).

certain critical mining consumables, such as steel grinding media and ball mills (Interview 057801).

c. Value chains with tier-3 mining companies

While the South African mining industry is still dominated by big blue-chip companies, in the recent past mining rights have been increasingly distributed to mid-sized and small miners, generally referred to as junior and emerging miners (MCSA, 2019). In 2018, these companies represented around 80% of domestic mining operations, but accounted for only a small percentage of total industry revenue and its operational and capital expenditures (MCSA, 2019). The relationships between local OEMs and tier-3 mining companies operating in South Africa and in the region tend to be relatively less asymmetrical and captive.

However, the limited geographical scope of many tier-3 miners' operations makes it difficult for local suppliers to scale up and introduce their innovations into global markets (Interview 014367). Moreover, since many of these miners have only limited access to funding and their operations are characterised by relatively short time horizons, their investments are generally considered non-profitable and highly risky by local OEMs. Chinese OEMs and lead TFSs tend to outperform South African suppliers along more price-sensitive MGVCs since they are able to offer mid-range equipment and appropriate modular solutions, backed by highly competitive financial packages specifically tailored to the needs and risk profile of this emerging client base (Interviews 025391 and 062765).

d. Value chains with Chinese mining investors

Between 2003 and 2018, sub-Saharan Africa accounted for one fifth of the total capital invested by Chinese companies in global mining operations (fDiMarkets, 2020). A key target area in the continent has been Southern Africa (Fessehaie, 2012a; Humphreys, 2015). A recent study reveals that between 1997 and 2016 the bulk of the majority-controlled Chinese gold, diamond and copper mines in sub-Saharan Africa were concentrated in Zambia, Zimbabwe, South Africa and the DRC (Wegenast et al., 2019).

So far, most South African suppliers have not managed to enter domestic and regional Chinese-led mining value chains. Many of the local OEMs interviewed are cautious about supplying Chinese mining operations to avoid, or at least contain, reverse engineering of their equipment (Interview 019078). Others have simply found it difficult to approach these emerging investors effectively (Interviews 0188345 and 062765). However, the increasing penetration of mining equipment produced in China has opened up the possibility for local manufacturers to partner with and represent Chinese OEMs in the domestic and regional market, supplying spare parts, and offering maintenance and training support on behalf of the overseas producer. This has provided them with a fast track to enter Chinese-led mining value chains in the region and with a strategy to cope with Chinese competition.

5.6.3 Upgrading trajectories and business strategies of South African manufacturers

The most frequent development trajectory identified in my sample of firms is the one combining product upgrading and a certain degree of inter-sectoral and functional upgrading. Six out of seven firms have been able to develop new products or improve existing ones on the back of their advanced technical know-how in product design and manufacturing engineering.

Product upgrading is achieved through three different strategic paths, all involving a significant degree of customisation: (*i*) by developing customised solutions, tailored to the specific needs and problems of individual clients, which are more efficient or productive than the standardised ones available in the market; (*ii*) by developing niche technologies particularly appropriate for specific local mining conditions; and (*iii*) by strategically specialising in key product ranges and target markets.

Five firms have also started to use the technical competences acquired through the production of mining-related technologies to enter different sectoral value chains (i.e., inter-sectoral upgrading or diversification).

Finally, all the firms in our sample have achieved a certain degree of functional upgrading through a gradual expansion or migration into higher value added operational after-sales activities. Local equipment manufacturers have followed two different strategic paths of functional upgrading: (*i*) by offering specialised after-sales services for proprietary equipment, and (*ii*) by abandoning the design and manufacturing of their own equipment, at least for certain specific product lines, and specialising in the after-sales support of foreign technologies.[171]

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[171] This last strategy may also lead to a downgrading trajectory in the medium to long term, with the abandonment of manufacturing resulting in the permanent loss of key production, and process and production, organisation capabilities.

5.6.3.1 Product upgrading strategies

a. Development of customised solutions to solve specific customer problems

A number of South African OEMs have pursued a strategy of product upgrading by designing and building customised machines and equipment (e.g., load haul dumpers – LHDs – continuous miners, screening solutions) based on the clients' specific needs and problems, and on the site's distinct geological characteristics. Following such a strategy, these companies have entered consolidated markets largely dominated by TFSs, where emerging Chinese OEMs are making significant progresses. High technological competences, like customisation, engineering, design and rapid prototyping capabilities, lie at the core of the product upgrading experience for these companies and have allowed them to enter established markets where foreign suppliers tend to offer solutions standardised to the average features of global mining operations. The cases of companies like A, B and C are prime examples of this successful product upgrading strategy.

A is a mid-sized company specialising in the design and manufacture of customised underground mining machines well-suited to the specific geological conditions of South Africa. Established in the early 1980s to produce r*oof-bolting equipment* for the underground domestic coal mining industry, over the years it has extended its range of equipment to cover the hard rock section of the market (e.g., gold, platinum, chrome, diamonds, among others) and many different products, including face drilling rigs, long hole drill rigs, dump truck and LHDs.

A's development and adaption of LHDs to specific mining requirements illustrates how product upgrading by customisation takes place. Over the last decade the company has designed and produced diesel-driven hydrostatic LHDs (with either air-cooled or water-cooled engines), tailor-made to suit the geological and vastly different mining conditions in South Africa. These machines have been mainly deployed in local mining sites of mid-tier domestic companies. Through a close collaboration process and strong partnership between the equipment manufacturer and the mining site's engineering teams, the LHDs have been tested, reengineered and, eventually, modified into customised machines perfectly suited to the specific conditions at different mines. This has been achieved through an iterative optimisation approach, involving the replacement of certain key components (e.g., the engine package) used during the initial stages of the trials with different ones that have more appropriate technical specifications.

In many instances, this customisation has not significantly improved the time and pace of mining, but it has led to substantial efficiency gains: the main difference between conventional machines previously deployed at the mine sites and ***A***'s hydrostatic equipment lies in their total lifecycle cost differential, namely the cost and the frequency of replacing key components (e.g., transmissions, talk converters and axles). ***A***'s tailor-made machines have proved to be far more robust and reliable in hard rock applications, with an average availability of up to 93%, well above the international benchmark of 85%.

B is a medium-sized company specialising in the design and manufacture of customised vibrating equipment solutions for the most extreme applications. Founded in 1976 as a warehouse for a German manufacturer of screening equipment, it started to design and manufacture its own products locally in 2008. While screening in heavy precious metals and minerals is ***B***'s strength, the company has recently moved extensively into softer commodities, like coal. At ***B***, for greenfield operations, product upgrading via customisation generally takes place through close collaboration with the engineering department of large project houses, during the study, design and testing phases.

However, ***B*** is primarily a specialist in brownfield operations. Over the past decade, it has successfully undertaken numerous large-scale retrofits of vibrating equipment in existing plant infrastructure, offering improved screening and feeding efficiency, and uptime, while lowering the total cost of ownership for the end-client. In a recent project, ***B*** has collaborated with a South African diamond operation to double its feed rate from 250t/h to 500t/h by designing and manufacturing a multi-slope banana screening machine, customised to fit the end-client's existing processing plant. In another case, for a domestic medium-sized coal mine, competitor equipment was replaced by custom-designed screens with optimised deck angles to significantly increase the tonnage processed.

The company's in-house flexible engineering offering is underpinned by advanced design capabilities and applied mineralogy know-how, which include the use of traditional Finite Element Analysis (FEA) and Strain Gauge Analysis (SGA) modelling methods to prove structural integrity and strength of the equipment, and to predict its motion throughout the entire operating process in the field.

C is a large company specialising in the design and manufacture of customised, application-specific equipment and consumables, with over 45 years of experience in the mineral processing industry. Its range of equipment covers many different products, including cyclones, spiral concentrators, sampling solutions and screening media, which are applied also to company ***B***'s equipment among others.

To understand how product upgrading by customisation takes place at ***C***, a case concerning the use of new technologies for rapid prototyping is particularly instructive. Around seven years ago the company adopted additive manufacturing technology to complement and strengthen its design capabilities, which at that time were primarily based on third industrial revolution virtual simulation technologies like computational fluid dynamics, computer-aided drawing (CAD) and trajectory modelling. The introduction of 3D printing, combined with older computerised technologies, has reduced the company's lead times for producing prototypes and testing them before full-scale manufacturing from six to eight weeks to two to three days. This, in turn, has also improved ***C***'s response time to customer requests and feedback, and the speed to market for newly developed or improved tailor-made products.

Over the last few years, the company has used its rapid prototyping capabilities to design customer-specific solutions for mining companies and project houses in South Africa and abroad, speeding up the time to market and reducing the overall cost of production. Recently, these capabilities have been successfully applied to the development of a customised spiral flow diverter for improving the performance of a unique spiral application for a Canadian client and solving a customer's specific problem related to the functioning of a cyclone in South Africa.

The product upgrading achieved by ***A***, ***B*** and ***C*** is, in all three cases, based on the ability to develop customised solutions rather than off-the-shelf products standardised to the average characteristics of global mining operations. However, the nature and complexity of the key products developed by the two companies, as well as the core technical capabilities which drive their product upgrading strategies, are very different. On the one hand, at the heart of the optimisation of the performance of extremely complex machines like the LHDs produced by ***A*** lies the company's advanced manufacturing engineering capabilities, nurtured by a process of trial-and-error experimentation and learning by doing at client sites. On the other hand, the equipment produced by ***B*** and ***C*** does not require advanced manufacturing engineering capabilities, so the incremental improvements achieved are primarily driven by the companies' advanced design and test work capabilities, backed up by in-depth applied mineralogy knowledge. ***B***'s design practices make extensive use of traditional third industrial revolution-type numerical methods to plan, control and simulate the behaviour of equipment and parts, while company ***C***'s custom design relies on the application of new additive manufacturing technology for rapid prototyping, together with more traditional virtual simulation systems.

b. Development of niche technologies for local mining conditions

Other South African OEMs have upgraded along the mining value chain by creating or specialising in a range of new technology niches. A prominent example within the South African context is represented by mid-sized companies such as ***D*** and ***E***, which design and produce hydro-hydraulic mining equipment. They emerged in the early and mid-1980s around the hydro-hydraulic research initiatives led by COMRO, with consistent support from the South African gold-mining industry (Pogue, 2008).

Adopting a particular form of customisation strategy characterised by the local specificity and appropriateness of their technological efforts, these companies have developed innovative solutions to extract the metal-bearing host rock which have several advantages over conventional oil electro-hydraulic equipment, including energy- and cost-efficiency, and improved environmental, safety and health performances (Fraser, 2010a, 2010b and 2014).[172] With respect to compressed air systems, these technologies have been proven to enhance energy-saving (up to 90%) and productivity (up to twofold).

Since the early 1980s, ***D*** has pioneered the use of hydro-hydraulic drill technology within the South African mining industry. Over time, it has developed equipment tailored to its specific domestic target market, which is characterised by deep level hard rock mining operations in narrow deposits, a fairly high labour intensity and a very specific set of skills, capabilities and infrastructures, all of which make large-scale mechanised mining methods less effective.

Company ***E*** emerged in 1985 and over the years has substantially extended its product portfolio, which now includes high- and low-pressure valves, drilling equipment, rock handling machines and devices, energy-saving products and water jetting. Besides mining products, ***E*** has also developed a domestic market leadership in high pressure water reticulation systems that allow customers to operate maintaining a safe infrastructure. Recently, it has worked on some innovative solutions based on hydro power to access and mine gold deposits at a very

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[172] Importantly, these water-powered technologies are clean, non-polluting, non-contaminating and environmentally friendly. They constitute a particularly interesting example of green innovations developed by local mining equipment suppliers from an emerging economy, as those identified by Aron and Molina (2020) in the Peruvian market. An analysis of these aspects is beyond the scope of this thesis, however a promising avenue for further research is to look at how these and similar green technologies might contribute to make mining in South Africa more environmentally sustainable.

deep level,[173] but these are still in a prototyping phase and the company lacks the scale and financial resources to bring those technologies to market.

Given the local nature of this technology niche, and the very specific technical capabilities needed to make water perform like oil, these companies have not to date faced intense direct competition in the domestic market, from global OEMs or from emerging country suppliers.

c. Strategic specialisation in key product ranges and target markets

Very few domestic companies have been able to enter the open-cast mining vehicles sector. It is a highly segmented market, where large TFSs are dominant with respect to premium and high-end equipment, and emerging Chinese OEMs are increasingly competitive in mid-range machines. It is characterised by relatively weaker regimes of appropriability and a more established technological paradigm with respect to other mining technologies, and global success is strictly linked to large economies of scale and standardisation.

Established in 1954, ***F*** is the most important local player with respect to above ground earthmoving vehicles for mining operations and one of the few national export champions in the broader South African mining equipment industry.[174] It is a large, family-owned company and its product upgrading experience is built upon a strategy combining product and regional end-market specialisation. In fact, the company is domestically and globally competitive in a specific range of products (i.e., mainly small- to medium-sized dump trucks, with a capacity range of 12 to 60 tons), where it holds a domestic market share of around 45%. Contrary to the leading large TFSs, like Komatsu and Caterpillar, which produce a full suite of surface mining machines, ranging from smaller trucks suitable for the construction sector to 300 to 400-ton trucks, F has strategically specialised in the small- to medium-sized dump trucks sub-segment. This, in turn, is a very much more competitive market at the interface between mining and construction equipment and it is globally dominated by 20 to 25 players, many of whom are, increasingly, Chinese companies (e.g., Sany, Liugong, XCMG).[175]

This specialisation strategy has led to significant and continuous product improvements in terms of overall efficiency, productivity, ergonomics, driver's comfort and safety, and it has been achieved through a process of concentrated R&D (e.g., around 90% of the total R&D

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[173] South Africa still has a huge amount of gold resources in the form of ultra-deep deposits (Interview 019078).
[174] For further details on this firm and its history see Kaplinsky and Mhlongo (1996).
[175] According to my interviews, Chinese players currently hold a combined market share of around 10% in South Africa and this figure is probably higher for the Southern African market, where Chinese investors in the extractive open-cast sector are particularly active.

spending of the company focuses on this product sub-segment), increased internal value addition capacity compared to other competitors, and the ability to design and manufacture specialised attachments, and customise standard products, to suit the needs and requirements of specific customers.

In fact, alongside this product specialisation strategy, ***F*** has also targeted specific geographical markets, accounting for a significant share of the global demand for this range of mining and construction equipment, with 70% of its market currently concentrated in the Northern Hemisphere (e.g., 50% of global demand for small-to-medium sized dump trucks is represented by the US and Canada), while Africa is not considered a promising area for targeting, partly because of its highly cyclicality and instability, and partly because of the increasing competition in the regional market from Chinese OEMs. The firm's entry into, and initial development within, the North American market was strongly supported by the use of a number of independent John Deere agents who, at that time, did not have machines equivalent to ***F***'s products in their portfolio. The association of ***F***'s equipment with John Deere's products allowed the company to create customers awareness and brand recognition in this new and demanding market. Today, ***F*** mainly uses its independent sales and distribution network in the export markets of interest.

F's product upgrading in this extremely demanding and competitive segment of the yellow goods' market is explained by its design and manufacturing engineering capabilities, which are at the heart of its sustained ability to innovate and to target specific market needs.

5.6.3.2 Diversifying outside mining: a note on inter-sectoral upgrading

Recently, a number of local companies have started to diversify outside mining, entering and growing into different sectoral value chains. This strategic path has been followed by five firms in my sample, mainly as a response to the increasing competitive pressure faced in domestic and third markets, and to the volatile nature of the demand for mining-related technologies, particularly in South Africa.

As an example, company ***A*** is currently venturing into the agricultural equipment market, developing a locally designed tractor. However, the project is still in a prototype stage (Interview 014367).

Over the last few years, a number of producers of hydro-hydraulic mining technologies, like companies ***D*** and ***E***, have been able to supply different sectors, such as the water, steel and transport industries. However, these projects still account for a very small percentage of their total turnover and, overall, the lateral migration of hydro-hydraulic mining technologies to other sectors has been extremely limited compared to its actual potential (Interviews 019078 and 019113; Pogue, 2008).

Another company pursuing a strategy of inter-sectoral upgrading has been company ***C***. Over a period of years, it has successfully supplied sectors other than mining, such as power generation, process water treatment, chemicals and defence and security. In particular, the diversification into this latter industry has been fuelled by the increase in Chinese competition in the market for ceramic wearing parts for mineral processing equipment like lined cyclones. According to interviews, the company's estimated that the drop in sales of standard wear ceramic applications attributable to price-based competition from Chinese products amounts to 50% over the last ten years. In fact, Chinese companies are extremely price competitive in the market for these standard and relatively simple components for mining equipment, where global success is closely related to large economies of scale and standardisation. In response to this competition, C has started to focus only on the engineered and customised ceramic wear parts for specific mining applications and on new niche markets like the one for armour protection products. Over the years, the company has supplied many military and defence agencies, domestically and abroad (Interview 017703). However, C's projects in other sectors only account for a small part of the overall group's business and its core is still in the mining and mineral processing industry (Interview 017701).

One of the most successful cases of diversification outside mining is company ***B***. In 2012, on the back of the declining and volatile demand originating from the mining sector, the company started to venture into different industrial applications, supplying fine separators and screen panels for commodities like sugar, coffee, clay, plastic pellets and metal powders, among others. This strategy of diversification has been pursued primarily by hiring specialised personnel from the target industries with the right expertise, skills set and market knowledge (Interview 018345).

Today this non-core business accounts for around 10% of total company revenues. Since 2017, the turnover from non-mining technologies has grown substantially, especially in the applications for the food industry, at a rate of 42% (Interview 018346). During the same period, the company has registered a turnover growth of 10% to 15% in core mineral processing applications. Over the next five to ten years, the company's aim is to move to a more balanced revenues split (e.g., 70% in mining and 30% in other industrial applications).

In terms of market share, B is still a marginal domestic player in this new market, which is mainly dominated by large multinationals like Russel Finex and the Bühler Group. However, the prices of B's products are extremely competitive and there is a promising outlook for both domestic and regional growth (Interview 018346).

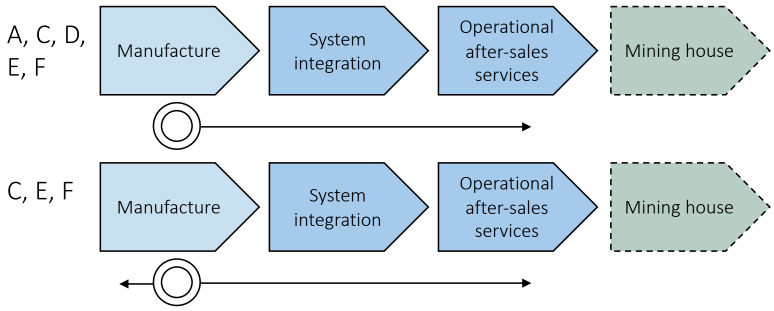
5.6.3.3 Functional upgrading into operational after-sales services

Originally, South African mining equipment producers were responsible for simply selling and replacing their machines. However, over the last ten to 15 years they have started to functionally upgrade, expanding the scope of their product offering to include higher value added operational after-sales services. This development trajectory has been driven by the combination of two interrelated dynamics. On the one hand, mining companies have faced strong incentives to increase the level of outsourcing of critical equipment and related services. On the other hand, certain first-tier competitors (i.e., large TFSs and emerging Chinese OEMs), through their transition towards the provision of critical services, have implicitly raised the requirements of operating the chain for other first-tier suppliers. As a result of these demand and competition forces, all the South African firms interviewed have developed their technical competences to offer their clients a whole range of after-sales services related to their products, including warranties, maintenance and repair, refurbishment, spare parts provision and operator support and training. To do this, they have followed two different broad strategic paths of functional upgrading.

a. Forward integration into operational after-sales services

Companies ***A***, ***B***, ***C***, ***D***, ***E*** and ***F*** have started a transition towards the provision of fully integrated solutions, expanding downstream from their traditional base in manufacturing to also offer after-sales services for their own proprietary equipment, designed and built in-house (see Figures 5.14 and 5.15). However, so far, they have not moved away from their heartland in manufacturing. Given their limited supply chain management and coordination capabilities, and their weak domestic supplier base (see the next sub-sections), they have not been able to outsource many of their key manufacturing activities in order to focus exclusively on higher value added systems integration. In a number of cases (i.e., ***C***, ***E***, ***F***) they have even integrated backwards into manufacturing their own components to ensure that these are produced exactly to their requirements (Interviews 017701 and 012398).

Figure 5.14. Forward integration into operational after-sales services: A, C, D, E, F.

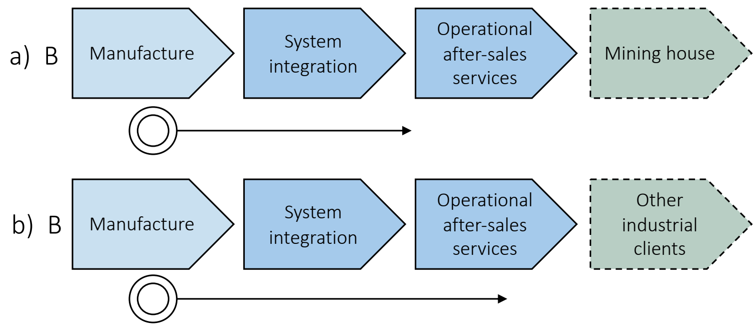


Notes: The continuous line indicates integration of new functions with original ones.
Source: Adapted from Davies (2004), based on own interviews.

All these firms, apart from ***B***, reported that their after-sales revenue streams are significantly higher than the initial capital cost of the equipment and cost of installation. The case of B is particularly interesting since, according to my interviews, the very nature of its equipment (i.e., vibrating screens and feeders) prevents the company from capturing the bulk of the after-sales revenue streams, which instead are very high for suppliers of consumables (i.e., screening media), such as company ***C*** (Interview 018345). ***C***, indeed, reported that the after-sales revenues for processing equipment consumables can be 13 to 15 times the initial cost for outright purchase and installation (Interview 017703). As a result, the potential for company ***B*** to evolve towards becoming a complete solution provider without integrating into the consumables business is limited (see Figure 5.15, diagram a), since it only deals with the substitution of the gearboxes and unbalanced motors, and the refurbishment of the screens (Interview 018346).

B's strategy of lateral migration into other industrial sectors is, indeed, also motivated by the possibility of capturing the bulk of the after-sales revenue streams in these markets, producing and servicing a range of screening panels for various industrial applications, alongside the screens (see Figure 5.15, diagram b).

Figure 5.15. Forward integration into operational after-sales services inside (a) and outside (b) mining: B.

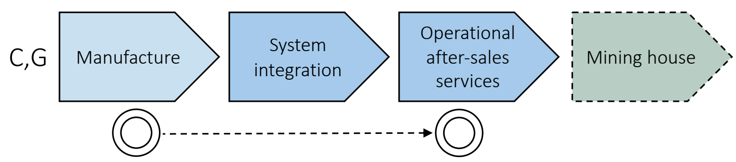


Notes: The continuous line indicates integration of new functions with original ones.
Source: Adapted from Davies (2004), based on own interviews.

b. Adaptive shift into after-sales services provision through strategic partnerships

The second path has been followed by two of the companies analysed. In this case, as a response to increasing competition, companies have repositioned themselves as after-sales services providers of foreign partners' technologies, ceasing the production of proprietary equipment, at least for certain specific product lines (see Figure 5.16).

Figure 5.16. Adaptive shift into after-sales services provision: C, G.



Notes: The dotted line indicates abandonment of original functions and migration into new ones.
Source: Adapted from Davies (2004), based on own interviews.

Over the past seven years, company ***G***, a supplier of mineral separation equipment, has strengthened long-term agreements with a number of leading Chinese producers of flotation equipment, and vacuum and pressure filtration machines. Under these partnerships, ***G*** provides after-sales services for these imported technologies, especially in the domestic and regional markets, but also in the Australian market, where the company has recently established a support facility. In 2018, ***G*** also established a new office in China to support its partners with a permanent engineering presence in the country, focusing on quality assurance and control (Interview 014529).

Company ***C*** has followed a very similar functional upgrading path for its magnetic separator equipment, a technology it used to manufacture and in which it had 30% of the local market before 2008 (Interview 017703). Then, as a result of the increasing Chinese import penetration in this segment, C decided to enter a technology and supply partnership with a Chinese manufacturer of magnetic separators, focusing on the installation, maintenance and refurbishment services (Interviews 017701 and 017703).

Admittedly, such repositioning strategies present an element of upgrading since these companies reported that they have moved to more profitable segments of the chain. However, such gains might be only temporary, as the loss of control over system integration and the manufacturing stages of the production process for complex capital goods could also lead to negative outcomes. Future investigations should aim at evaluating such a trajectory in the medium and long run.

5.6.4 Key internal and external barriers to value capture

However, despite these upgrading trajectories and the strong legacy in technology development capabilities, the South African companies interviewed have not been able to consolidate their competitive position, moving from local to global, especially in those value chains with the highest growth potential dominated by major global mining companies. Contrary to large TFSs and emerging Chinese OEMs, they have failed to enter into more fruitful bargaining processes with large chain leaders, moving from more asymmetric towards increasingly symmetric types of vertical relations along the hierarchy-market spectrum. At the same time, they have not been able to effectively respond to the increasing competition exerted by large TFSs and emerging Chinese OEMs.

The present analysis reveals that the value capture potential of local suppliers is actually constrained by a number of internal barriers, whose very nature is primarily non-technological and fundamentally unrelated to the technical efficiency of their products. They still lack those complementary capabilities which are crucial to offer a compelling value proposition to their clients and, in turn, to take full advantage of upgrading and innovation. As stressed by the head of project management and managing director of two local mining equipment suppliers:

> "Here in South Africa, our organisational and financial competences have not evolved with our technology. The current prevailing selling model is exactly the same as it was in the 1960s." (Interview 014529)

> "We can summarise our situation as follows: we are a medium-sized company with top-notch engineering and technological capabilities, but not really connected to an expansion and marketing programme.

> […] We constantly try to challenge those global gorillas from a technological point of view, by producing new, better and more efficient products, but the reality is that there is no competition at all: we are not even sitting at the same table." (Interview 014367)

To clarify this, table C.4.2 in Appendix C reports a stylised capabilities portrait of South African mining equipment producers.

Moreover, I also find that their market creation and value capture abilities are bounded not only by their internal organisational deficiencies, but also by the wider environment and institutional setting in which they operate. As the chairman of another local OEM put it:

> "The cost of doing business in South Africa is significantly higher compared to other places, because of the cost, quality and reliability of key inputs, the limited access to cheap capital, the lack of certain critical skills and good infrastructures." (Interview 012398)

In what follows, I examine the internal and external factors constraining local OEMs and limiting their ability to grow further, capture a greater share of the aggregate value and compete globally with lead first-tier suppliers. Specifically, the next sub-sections elaborate upon the firm- and systemic country-specific capabilities and complementary resources needed to enhance commercialisation and appropriability from it, effectively manage product variety, supply chain and operational after-sales services and, finally, secure funding and provide competitive vendor financing services. In fact, during my conversations with industry representatives, the building up and strengthening of key capabilities complementary to the core technical know-how in these five areas was identified as crucial for enhancing the competitiveness of local OEMs.

5.6.4.1 Enhancing commercialisation and appropriability from it

Notwithstanding their advanced capabilities in technology development, local firms face serious constraints when it comes to the commercialisation of new or improved mining-related solutions and demonstrating the value added of their innovative products to end-clients. Despite lacking a fully-fledged public technology infrastructure, they are quite well versed in indigenous technological experimentation and development of niche products. These companies, however, are relatively less capable of scaling up their production capacity and doing so in a cost-competitive manner.

In this respect, within the context of an industry where large customers are generally reluctant to try new technologies without a proven technical track record, local OEMs have identified the lack of access to appropriate testing facilities as one of the major constraints. In fact, new or improved technologies upscaled to real-world situations might interfere with mining cycles, negatively affecting the customers' revenue streams. Thus, the ability of equipment suppliers to test their products in house in an experimental real-world or virtual mining environment, and in close collaboration with end-clients, constitutes a significant competitive advantage in this sector (Interview 042347).

Compared to large, foreign first-tier suppliers, local OEMs have far fewer resources to invest in formal R&D activities, and fewer in-house experimental spaces and supporting infrastructures allowing them to test new technological systems without impacting on daily mine operations (Interview 062001). Especially for the most complex equipment, like underground machines and surface off-road vehicles, when improving current technologies or developing new products, local companies mainly focus on the design phase and shop-floor incremental innovation and efficiency development, while letting their customers test these newly released solutions in the field (Interviews 012398, 014367 and 017701). This obviously places local OEMs at a disadvantage compared to large foreign suppliers, especially TFSs, which are able to test their upscaled solutions in house without impacting on their clients' operations, and can offer them training assistance, demonstrations, showcases and active participation in technology development and improvement (Interview 042347).

The limited ability of South African OEMs to successfully commercialise the results of their upgrading efforts is further exacerbated by the declining linkages between industry and research institutions and science councils, not only in the mining sector, but also in related areas such as metallurgy and metal refining (Kaplan, 2012).[176] It was only with the launch of the Mining Phakisa initiative in 2015 that the government signalled a renewed interest in, and commitment to, the country's mining sector gathering together key stakeholders into a 'lab', with the primary objective of identifying constraints and building a common vision for the long-term development and transformation of the sector. Over the past few years, the recently founded MMP and the industry cluster of MEMSA have tried to strengthen the weak industry-research linkages in the country through a number of initiatives, including the building up of

[176] From the early 1990s, the Council for Scientific and Industrial Research (CSIR), which inherited the research mandate of COMRO after their merger in 1992, started to experience a severe downsizing: while up to the 1980s the co-investment between the chamber and member companies amounted to around R400 million (around USD 27 million) a year, the available funding declined substantially up until 2014, when only R5 million was allocated for mining-related R&D initiatives (Macfarlane, 2018).

a shared experimental test mine that will provide a protected real-world environment for South African OEMs to learn and innovate.

It is hoped that these coalition-building efforts will result in collaborative forms of R&D among South African companies and, eventually, the development of new marketable technologies for local conditions that can then be modified, scaled up and applied in other geographical contexts. However, at this stage, the Precinct is not properly funded. Furthermore, available resources should be directed to developing key technology infrastructures supporting innovative market-ready solutions for mines, and research personnel in these institutions must be properly incentivised and motivated to fill critical intermediate functions between companies and basic research within universities.

5.6.4.2 Managing product variety

The strength of South African mining equipment manufacturers in engineering-to-order and product differentiation is also mirrored in a proliferation of different products, as well as in a tremendous variety of parts arising from these companies' commitment to customised production and to testing solutions on clients' site. In a number of cases, components proliferation has literally exploded, with serious implications both for manufacturing and for operational after-sales services (Interviews 012398 and 019079). The engineering-to-order model behind the upgrading strategy of many South African OEMs has resulted in difficulties in estimating lead times, delivery dates, extensive reworking due to the late realisation of equipment failure during testing in the field, material wastage, sub-optimal product quality and inventory levels, and scalability constraints (Interviews 019079 and 014367). This has eventually undermined these firms' ability to respond rapidly to changing market requirements and volumes, and to enter international projects led by GDMCs and establish themselves in new export markets (Interviews 019078, 062189, 062765).

To overcome these challenges, a transition towards mass customisation could in principle provide engineering-to-order companies with some new instruments to manage product variety and secure reusability between solutions, while simplifying the manufacturing process and lowering the costs per unit produced (Haug et al., 2009). As already seen in Section 5.1, by looking at the development trajectory of many mining equipment TFSs, mass customisation principles like standardisation, modularisation and the use of configuration systems have become crucial aspects for more efficient sales and engineering processes, and, ultimately, for increasing competitiveness and value capture, especially in large international projects led by GDMCs.

Obviously, the willingness to apply a certain degree of mass customisation on the part of South African producers of highly complex and custom-engineered equipment would create the need for a change in the internal organisational layout and production flow to ensure the right balance between flexibility and standardisation (Haug et al., 2009). The key challenge during this shift towards mass customisation is to move the time of product differentiation much closer to the delivery phase. On the engineering side, this means that companies would need to standardise their engineering work to a partly predefined and fixed solution space, modularising their products' architecture. On the production side, they should be increasingly able to rapidly assemble-to-order rather than manufacture or source new components for each different order.

The ability of South African OEMs to effectively apply these principles also depends on the extent to which they are able to achieve systemic efficiency in their production chain. This, in turn, relies upon both the degree of their internal supply chain management and coordination capabilities (i.e., supplier development and supply chain integration competences), and on the quality, cost-competitiveness and reliability of their external supplier base (Interviews 019079 and 012398).

5.6.4.3 Managing the supply chain within a context of weak domestic upstream linkages

South African mining equipment producers operate with a very weak domestic supplier base. With only few significant exceptions (e.g., large steel suppliers), this is mostly composed of small and very small trusted companies producing and machining castings, providing sandblasting, and supplying welding equipment and some hydraulic parts for mining trucks (Interviews 012398 and 019078). The vast majority of these small domestic suppliers lack the internal capabilities and resources to upgrade in this competitive sector and are extremely dependent on the local OEMs: indeed, their supply relations with the equipment manufacturer constitute a significant part of their total turnover (up to two-thirds in some cases) and when it comes to investment decisions about the expansion and improvement of their facilities, local OEMs act as lenders and/or co-investors (Interviews 017701 and 019078).

E and ***C***, for example, to secure the supply of a critical component, decided to acquire shares in their supplier's business and to actively participate in its investments in technical upgrading

(Interview 019079 and 017701). In another case, ***C***'s demand for high precision manufacturing to mould internal frames has induced one of its suppliers to develop capabilities in robotic welding solutions (Interview 017701). However, in many instances, local OEMs lack the financial muscles, the organisational capabilities and the infrastructure to promote supplier development by themselves (Interview 014367).

At the other end of the domestic supplier spectrum, the dominance of a few large, transnational corporations in certain key upstream industries (e.g., basic iron and steel), and the resulting high concentration levels,[177] lead to frequent and sudden price increases imposed on equipment manufacturers on a 'take-it-or-leave-it' basis (Interviews 014367, 018345 and 019079). The confluence of the local content requirements and the strong power to influence market prices of local upstream steel suppliers has introduced an implicit obligation for local equipment manufacturers to pay a premium on the basic steel components sourced domestically. Local OEMs lack the bargaining power to effectively negotiate more favourable terms with these powerful actors and do not have any other domestic alternative to them (Interview 019078).

Given the weaknesses of the domestic supplier base and the limited internal supplier development capabilities of the majority of local OEMs, many components and raw materials are imported. For certain steel-made consumables (e.g., finer wire screen panels), rubber components (e.g., liners for cyclones) and other similar inputs, large-scale conditions prevent the profitable localisation of their production: alternatives shipped from China and other emerging economies are far more convenient and their quality is increasing (Interviews 017702, 018345 and 014367). Certain specialised raw materials (e.g., specialised types of steel such as duplex stainless steel) are generally imported from European suppliers, since they should fulfil very specific technical criteria because of the strict durability and resistance requirements associated with operating mining machines under extreme conditions (Interviews 012398, 017701 and 014367). Finally, a number of key components, such as engines and batteries for underground and surface machines, or unbalance motors and magnetic vibrators for vibrating processing equipment, are imported from foreign suppliers or sourced from their local representatives. The same applies to other components, such as tires, track and control systems for heavy earthmoving equipment and underground machines (Interviews 012398, 018345 and 014367). In South Africa these parts and raw materials are generally imported for different

[177] According to own estimates based on SARS (2019) data, the value of the Herfindahl-Hirschman index for the basic iron and steel sector (slightly higher than 2500) reveals very high concentration levels.

reasons, such as the lack of local capabilities to manufacture them domestically and the lack of sufficient domestic demand to keep prices competitive.[178]

In many instances, the current tariff structure tends to penalise leading local manufacturers like companies ***A*** and ***F***, which are forced to import key inputs from premium suppliers in Europe and the USA (e.g., tires, engines and certain specialised steel components), vis-à-vis foreign players shipping to the country already or ready-to-be-assembled machines (Interviews 014367 and 012398). Furthermore, these local companies, which rely heavily on key foreign suppliers, often face long lead times given the geographical remoteness of South Africa with respect to the origins of such imports. This, in turn, adds additional costs and complexity to the supply chain management and coordination process (Interview 012398).

In response to these issues, ***F*** has recently opened a German production site with the aim of strengthening its European foothold, moving closer to its key suppliers and transferring the manufacture of certain core components from its South African facility (Interview 012398). This gradual relocation strategy promoted by one of the national mining equipment champions signals, on the one hand, the company's commitment to its Northern Hemisphere clients, but on the other hand, implicitly highlights a number of the weaknesses of the South African mining equipment production system, including the small size of the domestic market and the lack of capabilities to locally manufacture crucial and high value added components.

Unlike large TFSs and many emerging Chinese OEMs, local mining equipment producers cannot rely on a structured supply chain consisting of a distributed network of manufacturing facilities and capable external suppliers located in their home countries and abroad. Thus, their inability to respond flexibly to the rapidly changing market environment and end-client requirements is not only constrained by their own internal inflexibility, but also by that of their supplier base at any tier.

As a final point, it is important to mention that the optimisation of linkages with suppliers also requires an integration of systems that allows access to information and data sharing across firms. Local OEMs do not yet have the internal capabilities to exploit advances in digital data to develop cutting-edge proprietary technologies for monitoring suppliers' performance, and successfully orchestrate the movement of parts to support lean and agile manufacturing and minimal inventory costs (Interview 017701). Standard technologies already available in the

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[178] Table C.4.3 in Appendix C lists a selection of components, classified with respect to their foreign and domestic content.

market are often not affordable by many medium-sized companies and their suppliers (Interview 062002).

5.6.4.4 Managing after-sales operations

a. Building up and managing a distributed network of sales and support centres

To be able to capture the life-cycle profits associated with the equipment and secure a more continuous stream of revenues, companies should also establish and manage a widespread network of distribution and support centres close to or even inside their clients' sites. Larger local companies, like ***B*** and ***F***, have a distributed network of local, regional and even global sales and support subsidiaries. However, smaller companies, like ***A***, ***D***, ***E*** and many others, do not have the financial muscle and organisational structure to establish and manage a large number of certified centres, especially abroad, and, thus, to provide quick and effective after-sales services. This, in turn, obviously reduces the possibilities for the bulk of South African suppliers to enter and expand into new export markets, and contributes to widening the competitive gap with TFSs and emerging Chinese OEMs (Interview 062765).

Over the past two decades, these foreign players have intensively invested in strengthening their international distribution networks and support facilities to be able to ensure next-day delivery of components and spare parts, and on-site maintenance and training provision for their clients' global operations, even in the most geographically remote locations. To be able to participate in international mining projects and enter new export markets, local medium-sized OEMs might initially partner with independent dealers of other brands, who have not competing products in their portfolio, as in the case of ***F***. Another possibility, which is also actively encouraged by the SACEEC, is to contribute to building distribution and support facilities to be shared with other non-competing local companies (Interview 062765).

These difficulties related to the limited internal financial and organisational capacity to undertake and manage investments in distribution and after-sales facilities are further exacerbated by the lack of an efficient and affordable external support system for export development in South Africa. This problem was raised by all the local companies interviewed as a major factor limiting their scaling up and export development potential. The current package of export finance and export support policies in the country is managed by different institutions, offering a number of services and programmes: these are the Export Credit Insurance Corporation (ECIC), the Industrial Development Corporation (IDC) and DTI.

However, according to the companies interviewed, the schemes proposed do not always take into account the specific needs of firms operating in the mining equipment sector, and do not sufficiently encourage the creation of collaborative arrangements providing 'export cartel' types of function. Furthermore, local companies have underlined two additional criticalities: first, export development support is not always affordable for medium-sized companies, given the high interest rates charged by the banking system in South Africa; and, second, state-sponsored financial instruments are not easily and quickly accessible, mainly because of the red tape, the sheer technicalities and the excessive bureaucracy that characterise these programmes. As an example, a number of companies reported that it took on average 18 months to get access to export finance deals underwritten by the IDC (Interviews 012398 and 014367). By contrast, TFSs from advanced countries and emerging OEMs from China can benefit from quick and easy access to their home country development and export finance institutions, which in turn provide them with extremely competitive state-sponsored export credit at low interest rates.

b. Adopting predictive maintenance and warehouse management technologies

The geographical remoteness of many mining operations also increases the benefits of adopting advanced intelligent technologies for predictive maintenance rather than time- or web-based maintenance programmes relying on manual inputs. To get the most out of predictive maintenance, it is also necessary to combine such tools with warehouse management technologies for monitoring, and coordinating spare parts and components stocks. In fact, it is essential that the maintenance teams working on the equipment have a clear overview of inventories and actively participate in their monitoring.

However, while certain companies, like ***A*** and ***C***, are currently working on a series of prototypes to equip their hardware production technologies with smart sensors, none of the companies interviewed has so far developed an in-house technology for remote predictive and preventive maintenance. Admittedly, company ***F*** offers a fleet management tool and cost-reducing predictive maintenance system for all types of machinery with oil-wetted components. However, the latter is managed and administered by an external network of condition monitoring laboratories and experts, mainly because of the lack of in-house capabilities in big data analytics.

The adoption of standard or proprietary technologies for warehouse management is also extremely limited among local companies, similar to the case of supply chain integration systems for monitoring suppliers' performance and coordinating upstream linkages. As already mentioned, the machines of large TFSs are equipped with proprietary monitoring and technologies that, combined with advanced warehouse management systems, allow them to offer more effective, quick and efficient maintenance and repairing services. The information obtained by large TFSs through the use of remote condition monitoring technologies, and the related in-house big data analysis capabilities, can be fed back into the design and production of current and future generations of equipment.

5.6.4.5 Securing affordable funding and providing vendor financing services

The most serious constraint to value capture, further growth and industrial scale-up mentioned by all the South African firms interviewed is their limited ability to secure funding for current operations and new investments, and to provide competitive vendor financing services to end-clients. While this is particularly the case for small- and medium-sized firms, larger local companies are also at a competitive disadvantage with respect to foreign suppliers in terms of financing capabilities, especially when competing in regional and global markets. The weak balance sheets of local suppliers do not allow them to invest in a number of complementary resources, technologies and capabilities which are crucial for their industrial success. And, indeed, as already seen, this is a limiting factor for local OEMs in their efforts to build up internal capabilities for successful commercialisation, supplier development, supply chain integration and operational after-sales services.

Financial services also play a crucial role in the negotiation stage when end-clients require assistance with financing the purchase of mining equipment and machines. In this respect, the ability of mining equipment suppliers to provide financial services to their end-clients is another fundamental capability for their successful transition towards the provision of fully integrated solutions. As already underlined, large TFSs are in a position to offer favourable equipment financing options, including low-interest loans, to facilitate the purchase of equipment through their in-house financial organisations. Over the past few years, emerging Chinese OEMs have also developed advanced transactional competences and are able to offer different equipment selling models, tailored to the specific needs of different mining houses. This obviously contributes to increasing the already high entry barriers for local equipment suppliers in different end-market segments, especially when dealing with international mining projects (Interviews 057802 and 012398). Local OEMs, indeed, are generally not in the position of being able to offer competitive rental and leasing agreements, mainly because of their limited balance sheets and the lack of in-house advanced transactional, contract design and technical sales competences (Interview 025392).

These difficulties related to a limited internal capacity to offer competitive equipment finance solutions are further exacerbated by the lack of an efficient and affordable external support system for industrial and vendor financing in South Africa. This problem was raised by all the local companies interviewed as one of the key binding constraints to their scaling up and export development potential. As has already been said, public financial institutions do not often have a sector-specific focus, so their schemes do not always meet sector-specific needs.

Furthermore, based on the information shared by the companies interviewed, another aspect undermining the industrial success of many local firms is the distorted functioning of the South African domestic capital market. This threatens the growth prospects of mining equipment companies (and possibly of companies in other sectors) in two different ways. First, the historically high real interest rates in South Africa hinder firms' capacity to invest in those key complementary resources, technologies and capabilities which are crucial for their industrial success. Second, the high level of industry concentration in the South African economy (Roberts and Makhaya, 2013) has led to uneven access to funding sources and differential interest charges to different parties (Kaplinsky and Mhlongo, 1996).

While this particular type of imperfection is not easy to document in practice, own interviews with industry representatives and public officers confirm its existence and relevance within the context of South Africa (Interviews 062189, 062003, 072001). The bulk of local mining equipment producers have no links to any of the major financial institutions or conglomerates and are therefore forced to pay very high interest rates (Interviews 019078, 012398, 014367). Moreover, besides those large South African firms which benefit from favourable access to capital domestically, the local subsidiaries of large TFSs and emerging Chinese OEMs are also supported by the financial resources of their parent companies abroad and by the favourable capital market conditions in their home countries (Interviews 025391 and 035203).

5.6.5 Discussion and policy implications

In this section I have characterised the structure of different South African mining equipment value chains, focusing on both the GVC governance patterns involving mining companies, project houses and immediate suppliers, and the rivalry dynamics between local first-tier suppliers, TFSs and emerging Chinese OEMs. Then, through selected firm case studies I have analysed the nature of the product, inter-sectoral and functional upgrading paths followed by the local suppliers in my sample, as well as the advanced core technical capabilities lying at the core of these trajectories. Finally, the analysis has revealed that the value capture potential of local suppliers is constrained by a number of internal barriers, whose very nature is primarily non-technological and fundamentally unrelated to the technical efficiency of their products.

Moreover, I have also shown that their market creation and value capture abilities are bounded not only by their internal organisational deficiencies, but also by the wider environment and institutional setting in which they operate. Specifically, the section has focused on the firm- and systemic country-specific capabilities and resources, complementary to the core technological ones, needed to enhance industrial scale-up, commercialisation and appropriability, to effectively manage product variety, supply chain and operational after-sales services, to secure affordable funding, and to offer competitive vendor financing packages to their clients.

Against this background, industry representatives also underlined how sector-specific policy interventions are crucial for strengthening firms' capabilities in these five areas and thus the competitive position of South African OEMs, especially in regional and global markets. In this respect, as the managing director of a local OEM put it:

> "Without any political will to level the playing field, to preserve and strengthen South African capabilities, the risk for a company like us is simply being locked in a trajectory of diminishing returns driven by a constantly shrinking base of potential customers. Being a company with advanced technical product design capabilities operating in a specific market niche, we can always find an opportunity and survive. But competing globally is much harder." (Interview 019078).

Based on the analyses conducted above, in what follows I briefly discuss five policy actions for feasible reforms in the South African mining equipment sector. These have been inspired by continuous interaction with industry representatives and policy officers between January and October 2019, and by the review of a number of international policy experiences (i.e., Australia, Finland, Chile).[179] Obviously, their effectiveness will be also affected by the evolution of the broader South African industrial ecosystem and the broader industrial policy package within which they operate.

[179] An extended version of these policy recommendations has been developed in a background paper prepared for the South African Mining Equipment Master Plan (Andreoni and Torreggiani, 2020).

5.6.5.1 Promoting technology innovation with a focus on scalability, commercialisation and appropriability

The Mandela Mining Precinct should be elevated to a specialised intermediate technology institute housing and integrating fragmented initiatives across the mining industry. It should focus on the opportunities offered by global mining megatrends (CSIRO Futures, 2017), addressing the challenge of scaling up national OEMs and their suppliers, and promoting collaboration across domestic and foreign players.

As discussed above, while South African mining equipment companies show a relatively high level of core technological capabilities (i.e., technical mastery in terms of product conception, design and development), they lack a number of capabilities needed to compete internationally in this industry. In fact, producing an advanced technology solution at scale and under specific price competitiveness parameters is much more than being technologically innovative: it is about addressing manufacturability challenges.

These scale-up issues can be tackled by providing dedicated technology services, as well as providing companies with access to quasi-public goods technologies, such as data systems, testing facilities and pilot lines for virtual design and prototyping of mining solutions. In some cases, these initiatives may perhaps not be sufficient. In this case, following the model pursued by the Resources Sector Supplier Envoy established in Australia (Andreoni and Torreggiani, 2020), the specialised institute should also promote collaborative arrangements (e.g., JVs and consortia) across different domestic and foreign players.

5.6.5.2 Reforming tariff schedules selectively

The existing tariff schedule presents a number of challenges for local OEMs, as discussed in Section 5.6.4.3, including the fact that final products are offered more favourable tariffs than certain key inputs and components. The reform of the tariff schedule for the mining equipment value chain should allow for two important policy functions.

First, tariff schedules should be reviewed in view of implementing an export promotion model and in conjunction with the local content requirements, identifying:

- products on which tariffs will apply for the purposes of a localisation or export policy;
- appropriate local content targets for different product segments;
- incentives for prioritised capability development areas;
- benchmarking possible tariff rates against local content of South African firms; and

- appropriate areas for implementing export rebates.

Second, a more targeted set of tariffs should be set based on an assessment of the local supply chain capabilities and specific product segments for which domestic producers have a chance to be competitive internationally. This assessment should start from the identification of the key beneficiaries of tariffs along the extended metal and mining equipment value chain. In those cases in which the beneficiaries have benefitted from rents, but have captured them in an unproductive way – that is, rents generated through tariff protection have not been reinvested – government should discipline the rents by removing tariff protections. Following on from this first assessment, the tariff reform should prioritise those intermediate and final product segments in which local companies have already developed distinctive capabilities and are close to the international price competitiveness benchmark.

5.6.5.3 Support in export markets

The current South African export support policy package only partially meets the needs of local OEMs. First, with the exception of IDC's strategic business units, financial institutions do not have a sector-specific focus, hence their financial schemes and products do not always meet sector-specific needs. As discussed in 5.6.4.5, vendor financing solutions are becoming a major non-technological competitive factor, especially in international markets. In this respect, IDC should explore financial options available to support domestic companies with proven capabilities to further enhance their product value proposition with a financial product package.

Second, to be effective, financial institutions must provide sector-specific products and solutions that are also affordable. The affordability problem was raised by several companies as a major factor limiting their industrial scaling up and export development. Improvements in this area will ultimately rely on a broader reform in the banking sector, promotion of competition and tailored industrial development finance. In this respect, the establishment of mutual credit guarantee consortia among companies, especially small and medium-sized ones, may alleviate the financial constraints they face. Known as 'confidi', these credit guarantee consortia have played a major role in Italy and reduced the pressing conditions posed by banks on firms (Andreoni and Torreggiani, 2020). Furthermore, credit guarantee schemes backed up by the government could also lower the cost of capital, providing further relief for companies in terms of improved affordability.

Third, while posing some conditionalities on local content, the currently available credit insurance scheme and the other financial support schemes do not sufficiently encourage the creation of collaborative arrangements providing similar functions to export cartels. Access to export finance could be tied or made preferential in case of companies developing joint initiatives to penetrate regional and international markets. In particular, drawing from the experiences of incentive schemes in Chile and Finland (Andreoni and Torreggiani, 2020), hybrid incentives and procurement policies can be important instruments to foster domestic supply chain development and collaboration across mining houses, OEMs and broader actors in the industrial ecosystem.

5.6.5.4 Promoting related diversification with a challenge competition fund

Within a context of increasing competition and stagnating mining investments in the country, it is of vital importance to promote related diversification for mining equipment producers, focusing in particular towards those closely related sectors where domestic players could redeploy their capabilities. Building on the methodology developed in Andreoni (2018), the following related industries have identified as particularly promising: the agro-industrial sector (both harvesting and sorting/processing machinery), the construction equipment sector and the off-road transport equipment sector. Following the proposal by Kaplan (2012), the government could promote the launch of a challenge competition fund in partnership with private companies in these related sectors. The challenge competition fund should work as a market creation tool, based on specific procurement needs and specifications from private companies operating in related sectors.

5.6.5.5 Strengthening the skills fabric

Most of the firms interviewed made reference to the lack of skills in the sector as one of the key binding constraints on their growth. Skills shortages were said to be particularly severe with respect to highly qualified data scientists, technical sales professionals, and mechanical, structural and electrical engineers, as well as artisans such as welders and boilermakers. Skills pose a policy challenge which requires targeted responses, both through existing institutions – like the Mandela Mining Precinct – and potentially new ones, delivering specialised apprenticeships schemes and technology services in close collaboration with universities, the Sector Education and Training Authorities (SETAs) and the Technical Vocational Education and Training (TVETs) colleges.

5.7 Conclusions

Adopting a detailed micro-level case study perspective, this chapter has provided important insights on the effects of the increasing involvement and upgrading of China in the mining equipment GVC for South African mining equipment producers. This question has been analysed in the wider context of the ongoing transformation characterising the mining equipment value chain at the global, regional and local level.

In fact, in the first empirical section of this chapter (i.e., 5.5) I have shown how the increasing Chinese involvement and upgrading along the mining equipment GVC has been driven by, and strongly interrelated with, other key restructuring dynamics taking place within this sectoral GVC, particularly the rising market influence of a number of TFSs. Both emerging Chinese players and incumbent TFSs have been able to exercise different forms of power along the mining equipment value chain, albeit to varying degrees. The deepening of GVC-specific capabilities has allowed these firms to follow distinctive upgrading paths and at the same time to capture the life-cycle profits associated with the equipment. On the one hand, this has strengthened their direct bargaining power along mining equipment value chains, increasing dependency of the lead mining companies and project houses, and reshaping the polarity and power configuration within the chain. On the other hand, the development of these capabilities has allowed these suppliers to reshape the horizontal competition dynamics at the first-tier level. They have been able to exercise increased diffuse and demonstrative forms of power by raising the bar for South African mining equipment manufacturers, by establishing higher de facto requirements of operating the chain.

The second empirical section of the chapter (i.e., 5.6) has provided a detailed description of the structure of the South African mining equipment value chain, and its ongoing evolution. Through case studies, this section has also highlighted the emerging mix of upgrading strategies pursued by South African OEMs over the past few years and which capabilities have they developed. I have shown that, while South African mining equipment companies exhibit a relatively high level of core technological capabilities, they often fail to capture the value they create through upgrading efforts. In fact, they struggle to access and control those capabilities and resources complementary to the core technological and production-related ones needed to develop effective commercial strategies in this sector. I found that these difficulties are the result of factors that are both firm- and country- or ecosystem-specific (i.e., internal and external to the firm respectively), and need targeted industrial policy actions to be overcome.

The chapter makes a number of contributions to the literature. First, it analyses the transformation of the global mining equipment industry through the lenses of a novel 'augmented' GVC framework, focusing on the sources and the impact of supplier firms' agency. Close to the spirit of recent contributions at the interface between GVC literature and international business studies (Sako and Zylberberg, 2019; Raj-Reichert 2019a and 2019b), this perspective emphasises the role of dominant incumbent TFSs and powerful emerging Chinese suppliers in producing changes in the value chain polarity and competition dynamics, and in raising the bar for suppliers in developing countries to enter, upgrade and capture value along the chain. Second, it identifies the main set of strategies pursued by South African equipment manufacturers to navigate the rapidly changing business environment within the industry. Third, through qualitative case studies, the chapter provides an assessment of how limited access to capabilities and resources complementary to firms' core technological ones plays a key part in preventing local suppliers from leveraging opportunities for value capture from their investments in upgrading. These findings, in particular, suggest that the debate on upgrading along GVCs, within the context of the rapidly changing nature of competition in global industries, should include, to a greater degree, considerations other than those relating exclusively to the development and the accumulation of core technology- and production-related capabilities, as in the previous literature on this subject matter (Pietrobelli et al., 2018; Molina, 2018; Stubrin, 2017). Finally, at a more general level, this empirical work also relates to key recent contributions around the debate on the middle-income trap (Paus, 2019; Raj-Reichert, 2019b; Andreoni and Tregenna, 2020), showing that the ongoing transformation processes within global industries, particularly the increased role of certain corporate actors in specific MHT manufacturing sectors, heighten the structural transformation challenges faced by many middle-income countries.

In light of the discussion and evidence presented in this chapter, five areas of future research are identified with the aims of expanding the scope of the present study and overcoming its limitations. First, a greater integration between existing GVC approaches, the technology capability framework and the international business and general management literature is desirable. Although a potential framework has been sketched in Sections 5.2 and 5.3, this is still in its embryonic stage, incomplete and quite sector-specific. Although recent attempts in this direction can already be seen in the literature (Sinkovics and Sinkovics, 2019; Sako and Zylberberg, 2019; Raj-Reichert 2019a; Golini and Kalchschmidt, 2019; Whitfield et al., 2020), this field represents an extremely promising area for further research in the near future.

Second, due to practical constraints, important stakeholders have been excluded from the present analysis. As discussed in Section 5.4, Chinese mining investors were not interviewed in person. Moreover, only a few second- and third-tier suppliers of domestic and foreign OEMs were interviewed. Additional investigations should triangulate the study's results with information shared by these actors.

More generally, future research should replicate the findings presented in this chapter, widening the sample base and the sector coverage in South Africa.

Furthermore, future research should also replicate this approach for mining equipment producers from other resource-rich, middle-income economies (e.g., Peru, Brazil, Chile). A comparative analysis of this type would reveal how the specific country context of social, cultural, economic, and political factors shape the accumulation of key capabilities, the upgrading and value capture trajectories, and the binding constraints for firms across different mining equipment sectors. It may also highlight how different policy approaches can influence the way in which these constraints can be effectively tackled.

Finally, this chapter has not directly addressed any of the questions risen by the recent debate on the contribution of mining activities to green growth and sustainable transition (Olsson et al., 2019; Sekar et al., 2019; Carvalho, 2017, Montmasson-Clair, 2015). In fact, the role of the mining sector in this area is quite controversial and multifaceted. On the one hand, the transition to low- or zero-carbon energy systems and the fulfilment of the climate-related requirements adopted in the 2030 Agenda of the United Nations will require large amounts of material resources. It is likely that the global demand for rare earth metals like indium and neodymium or for other minerals (e.g., zinc, silver, lithium, lead and platinum to name a few) will increase significantly in the next years (Drexhange et al., 2017). On the other hand, mining operations are associated with a large range of sustainability issues, including negative local environmental impacts and significant emissions of green-house gases (Azapagic, 2004).

Given the focus of the present chapter, future research related to the green-growth dilemmas of the mining sector should investigate to what extent mining equipment suppliers are able to develop green innovations that might contribute to make mining in emerging countries more sustainable. More generally, it would be also interesting to identify the internal and external factors that can foster or prevent the emergence of green innovations along the mining value chain in these economies (Aron and Molina, 2020). Within the South African case, this thesis has briefly dealt with two examples of green mining technologies (see the cases of company D and E, at footnote 172). However, more detailed research is needed in this area to better understand the interplay between mining, industrial development, trade, and sustainable transition in the country, particularly with respect to the potential risks and opportunities.

Chapter 6

Conclusions

6.1 Introduction

The aim of the present thesis has been to provide new empirical insights into the effects of the dramatic increase in China's export and production capacity on the development dynamics in the manufacturing sector of another G20 middle-income country like South Africa. The empirical analysis has been restricted to the post-apartheid period, when China's global expansion accelerated and concerns over its potentially negative effects on the domestic industrial system were raised within and beyond academia.

So far, a number of empirical contributions have deepened our understanding of the effects of the rise of China on the South African manufacturing sector. However, on the one hand, cross-sectoral studies have mainly used aggregate industry- and product-level data without exploring in detail the heterogeneous dynamics at the firm and sub-sectoral level (Edwards and Jenkins, 2014 and 2015; Jenkins and Edwards, 2015), while, on the other hand, sectoral case studies have exclusively focused on low capital- and technology-intensive manufacturing industries, such as textiles and clothing (Morris and Ehinorn, 2008; Bonga-Bonga and Biyase, 2019). The empirical evidence collected in this thesis has started to fill the knowledge gaps identified in the literature in the following two ways: first, by analysing the heterogeneous effects produced by China's increased exports and production capacity at the level of the firms (Chapters 3 and 5) and sub-sectors (Chapters 4 and 5); and, second, by focusing on the specific dynamics and trajectories characterising relatively more technology-intensive sectors (Chapters 4 and 5).

I have found that the impact of the rise of China's export and production capacity on the South African manufacturing sectors has been mainly competitive, both domestically (i.e., direct competitive effect) and in foreign markets (i.e., indirect competitive effect). Over the past two and a half decades, and specifically during the most recent period after the GFC, China has increasingly become a competitor for South Africa-based manufacturing firms, for South Africa-based exporters of MHT manufacturing products and for South African producers of mining equipment machines. Manufacturing firms registered in South Africa have seen a contraction in terms of their growth potential due to increasing Chinese import penetration of manufacturing products in the country. South Africa-based exporters of MHT manufacturing products have experienced a decline in their exports to third markets, due to increasing Chinese exports in the same product categories and to the same destinations. Finally, despite their strong core technological and production-related capabilities, South African producers of mining machines and equipment have seen their value capture potential along the value chain constrained by a complex combination of factors, including the increasing Chinese involvement in global and regional mining equipment value chains.

This concluding chapter is structured as follows. Section 6.2 presents a summary of the research conducted in this thesis and its main results. Section 6.3 discusses the possible theoretical, methodological and policy implications of this research work. Finally, Section 6.4 concludes, discussing the main limitations of this thesis, including a number of emerging issues not covered by previous chapters, and some possible avenues of future research.

6.2 Research summary and main findings

This thesis is divided into six chapters. Having briefly presented the main debate and stylised facts that motivate this research, its main objective, key contributions and structure in Chapter 1, Chapter 2 discussed in detail the research approach characterising this work and its methodological underpinnings. In particular, I supported the adoption of an original multi-methods research approach, considering its benefits when conducting empirical research at the interface between international trade and industrial development in an emerging country like South Africa. I also defended why and to what extent the use of econometric analyses in combination with mixed methods sectoral case studies has been particularly suitable to look at a multifaceted phenomenon, thus, presenting a more comprehensive picture of it. The main body of the thesis is then composed of three interdepended chapters (Chapters 3 to 5). Each analysed the research topic of this thesis from a different angle, using a number of distinct data sources and research techniques.

In Chapter 3, I analysed the impact of increasing Chinese import penetration on the growth dynamics of the entire population of manufacturing firms registered in the country, over the 2010-2017 period. To this end, first, I established a distinction between the impacts of direct and indirect Chinese import penetration along domestic value chains. I considered its effects on South African firms whose output directly competed with such imports (i.e., direct import penetration) and the way its impact spread from one South African firm to others through input-output linkages along domestic value chains (i.e., indirect Chinese import penetration propagating from upstream and downstream sectors). Secondly, I investigated whether firms investing more intensively in the accumulation of certain productive and technological capabilities (i.e., process and product innovation, and skills development), were more resilient to such competitive pressure and/or in a better position to benefit from the increased availability of cheaper inputs.

The empirical results showed that rising exposure to Chinese imports – not only direct ones, but also in downstream segments of the domestic value chain – led to a reduction in sales and employment growth for the entire sample of surviving firms and to a higher probability of dying for firms not undertaking significant investments in the development and accumulation of these types of capabilities. However, the chapter also found that, within industries, firms investing relatively more in skills development, and product and process innovation, were more likely to survive and grow despite rising competition from Chinese imports. Nonetheless, these positive effects are rather weak and unable to counterbalance the negative impact of Chinese import penetration. As a final result, it is worth to mention that the increased availability of cheaper inputs from China in upstream segments of the domestic value chain did not appear to have any significant positive impact on the growth dynamics of firms in downstream stages of production.

Chapter 4 analysed the potential displacement or complementary effect on South African exports in selected manufacturing MHT sub-sectors arising from growing Chinese imports in international markets in the same product categories, over the 1995-2018 period. The empirical investigation was conducted at different levels of disaggregation. The results show that, overall, Chinese exports of MHT manufacturing products have displaced competing South Africa exports in third countries over the 1995-2018 period. However, a substantial degree of heterogeneity has been found across sub-sectors, sub-periods and destination markets. China's crowding-out effect on South African exports affected more some specific sub-sectors (e.g., iron and steel, household appliances, metalworking machinery and machine tools, chemicals and electrical machinery) and destination markets (e.g., non-OECD countries, African and sub-Saharan African economies in particular). Furthermore, my estimates revealed that this displacement effect is more severe when exports from Hong Kong are combined with those from mainland China, and when analysing only the sub-period after the GFC.

Finally, among all medium-technology exports, mining equipment products have been characterised by an interesting path over the past two decades. In fact, between 1995 and 2006, South African exports of mining equipment goods proved to be sufficiently competitive on international markets with respect to the products exported by China. However, between 2010 and 2018, I found that this trend has reversed.

Moving from this evidence, Chapter 5 analysed the main reasons behind the ongoing stagnation of the South African mining equipment sector, despite the strong core technological and production-related capabilities of its domestic supplier base. By focusing on a specific MHT sector, I have been able to broaden the scope of the analysis in this chapter, and therefore to look at key aspects of the rising Chinese influence not explored in previous chapters.

In this third study, the increasing Chinese involvement in global and regional mining equipment value chains was investigated together with other intertwined global restructuring trends (i.e., the increasing market dominance of a small number of TFSs), and the specific internal and external binding constraints affecting the performances of domestic producers. The empirical evidence is based on 49 semi-structured interviews and two focus groups conducted with industry stakeholders in South Africa during 2019.

A first series of findings underlined the role of dominant incumbent TFSs and powerful emerging Chinese producers in shaping the power and competition dynamics along the value chain, and in raising the requirements for suppliers in developing countries to enter, upgrade and capture value within it. A second set of results emphasised that, within this evolving competitive landscape, it is vital for South African suppliers to accumulate and strengthen a set of key sectoral GVC-specific capabilities, complementary to the core technological and productive ones, to maximise value capture and enter into fruitful bargaining processes with the chain's leaders (i.e., mining companies, project houses, powerful suppliers).

6.3 Research implications

6.3.1 Theoretical and methodological implications

On the theoretical side, Chapters 3 to 5 have shown the value of enriching more standard mainstream analyses of trade- and GVC-related impacts of the rise of China with key considerations drawn from alternative analytical frameworks and streams of the literature, including evolutionary and structuralist economics, as well as international business and general management studies. More specifically, the analyses conducted in Chapters 3 to 5 highlighted the importance of taking into account aspects that are often neglected by more standard mainstream empirical studies on international trade and industrial development. These refer to the following three elements: first, the sectoral heterogeneity based on the special properties of certain relatively more technology-intensive activities; second, the firm heterogeneity based on their capabilities; and, third, the complex interactions among system components through linkage effects and interdependencies between sectors, activities and actors.

As far as the first aspect is concerned, a strict application of neoclassical trade theories would lead to all sectors being treated as equals in terms of their contribution to international competitiveness, calling to mind the statement attributed to Michael Boskin, according to whom there was no difference between producing potato chips or computer chips (Thurow, 1994). Within this perspective, which is rather agnostic in terms of the quality of the products traded, specialisation along comparative advantages would always be the best path towards growth and prosperity for countries, whatever the specific outcome of the specialisation process. According to this view, resource-rich developing countries, in particular, should specialise mainly in the production and export of unprocessed low-value added raw materials, natural resources and agricultural products. Comparative-advantage-conforming strategies are also at the core of the new-structural economics tradition (Lin, 2012). While this research project claims a return to a 'structural' understanding of economic development processes, with a renewed emphasis on the importance of industrial policy, the orientation of the Lin's framework remains one of latent conformity to comparative advantage and trade openness. More specifically, Lin's new structural economics recommends only minor and incremental deviations from comparative advantage: within this framework, the state's role is to anticipate and project future comparative advantage patterns and to facilitate the private sector in structuring productive activity according to them (Lin and Chang, 2009; Fine and Van Waeyenberge, 2013; Andreoni and Chang, 2019). A practical tool to guide policy makers in this incremental industrial diversification process has been developed by the literature on the product space (Hidalgo et al., 2007; Hidalgo and Hausmann, 2009), which maps the 'distance' between all exported products and identifies in their 'relatedness' the key driver of changes in the revealed comparative advantages of countries.[180] Within this framework, strategies of

[180] Within this approach, the proximity between products is defined in terms of the type of the final products, rather than in terms of the technologies used to produce them. It is important to bear this aspect in mind when thinking about the relatedness and the unrelatedness of products, since this distinction might arise from a misleading understanding of the relations and interdependencies between different sectors (Rosenberg, 1982;

related diversification are generally supported, since it is claimed that it is more difficult for countries to move towards unrelated products, and therefore policies promoting large leaps are more challenging.

On the contrary, in this thesis, the choice of focusing on MHT manufacturing sectors (Chapter 4), and within them on a specific segment of the non-electrical machinery and equipment industry (Chapter 5), has been inspired by an interpretation of economic development stemming from a synthesis between evolutionary and (old-)structuralist approaches, according to which sectoral specialisation patterns bear important implications for international competitiveness. Specialising in more sophisticated and technology-intensive activities, characterised by higher growth rates and dynamism, income elasticity of demand and learning potential, is more likely to result in higher growth, wealth and wages prospects for the entire country (Nelson and Winter, 1982; Fagerberg, 1988; Dalum et al., 1999; Lall, 2000; Fagerberg et al., 2007; Cimoli et al., 2009; Lin and Chang, 2009). Building on these alternative perspectives, the analyses conducted in Chapters 4 and 5 call for a much more focused study of more technology-intensive sectors and value chains in emerging countries – irrespective to their relatedness with existing areas of comparative advantage –, to understand the opportunities and constraints for their development, upgrading and competitiveness. Expanding these types of activities by acquiring new technological capabilities also through ambitious jumps in unrelated areas is, in turn, of paramount importance for developing countries with large endowments of natural resources in order to be able to defy their comparative advantage (Lin and Chang, 2009), and thus, to diversify their economy and promote new quality job opportunities (see Section 6.3.2 on this). The evidence of China increasingly becoming a strong competitor specifically in these industries for other emerging economies like South Africa (Chapters 4 and 5) makes the need for focusing on the development prospects of these sectors even more pressing.

Second, so far, more standard mainstream applied studies of the impact of Chinese import penetration on firms' performance and growth dynamics have mainly focused on the differences between capital- and skill-intensive firms, and large and small firms. Recent analyses have also looked at the differential impacts on firms with larger and smaller R&D stocks. In Chapter 3, novel dimensions of firm heterogeneity have been captured by studying whether firms investing more intensively in the development and accumulation of certain

Andreoni, 2014; Andreoni and Chang, 2019). While of great importance, a discussion on this aspect is out of the scope of the present work.

capabilities – namely process and product innovation, and skills development – have been more resilient to the competitive pressure stemming from China.

This has allowed for testing some of the hypotheses advanced by evolutionary, resource-based and capability theories of the firm (Penrose, 1959; Amsden, 1997; Dosi et al., 1990, 2000; Lall, 1992, 1999; Teece, 1986; Lin and Chang, 2009), which suggest how firms' responses to competitive pressure are highly heterogeneous as they critically depend on their different capabilities. The empirical results have confirmed the value of including such variables in the analysis, and in fact the chapter showed that firms devoting substantial resources to these activities are relatively more resilient to the increasing Chinese competitive pressure. However, these positive effects are rather weak and unable to counterbalance the negative impact of Chinese import penetration. This last finding points to the fact that firms might fail to adequately respond to the increasing Chinese competition if their investments in capital, technology and skills are not backed up by efforts aimed at developing other complementary capabilities and resources, which, in turn, are rather sector-specific.

A key implication of this result for theory development is that more granular deep dives into the reality of specific sectoral value chains and firms operating along them are needed. Building on this evidence, Chapter 5 took a first step in this direction by developing a sectoral GVC-specific capability matrix for the mining equipment industry. This allowed the heterogeneous responses of local firms to the evolving competitive landscape in the sector, as well as their effectiveness, to be captured and disentangled.

Third, this analysis also looked at complex interactions among system components, through linkage effects and interdependencies between sectors, activities and key actors. Chapter 3 took into account the impact of indirect Chinese import penetration and competitive pressure spreading from directly affected firms to others through input-output linkages in downstream and upstream industries. The importance of disentangling the impact of this form of indirect import penetration was inspired by structuralist multi-sectoral models and structural development economics literature. This emphasises the importance of these intersectoral linkages in countries' economic structures and how a number of different shocks (such as targeted policies, investments, opening to trade, linking to GVCs), acting upon these industrial interdependencies, might force countries towards extremely diverse development paths (Hirschman, 1958, 1997; Chang and Andreoni, 2020). However, the inclusion of the indirect import penetration variables in the econometric model also contributes to building a bridge between the analysis conducted in Chapter 3 and the literature on complex systems in economics, in particular with respect to those studies focusing on the diffusion of shocks in complex input-output networks (Contreras and Fagiolo, 2014). These empirical applications might, in turn, further enrich econometric analysis of the effects of international competition on domestic industrial systems.

Along similar lines, Chapter 5 developed a novel GVC interpretative framework taking into account sectoral linkages and interdependencies among different activities, as well as the specific structure and quality of the patterns of interactions between key actors along the chain. With respect to the first aspect, research conducted in this chapter has a direct relevance for the literature on the emerging phenomenon of the "servicification" of manufacturing and its implications for the participation of emerging economies in many GVCs (Gereffi and Fernandez-Stark, 2010; Hernández et al., 2014). In fact, through the discussion of the increasing importance of different types of services[181] in the production and export of mining machinery, it has been possible to analyse the new challenges and opportunities faced by emerging countries participating to these GVCs. As far as the second aspect is concerned, the chapter also takes forward some of the most recent advancements in the literature on governance in GVCs (Dallas et al., 2019; Ponte et al., 2019). This is done by looking at the specific forms of power that different firms might exercise along the chain, in an emerging country context and for a specific medium-high technology GVC.

The theoretical framework developed in Chapter 5, indeed, was sketched out by integrating a number of different theoretical insights drawn from existing GVC approaches, the technology capability framework, and the international business and general management literature. This framework proved to be a useful tool for analysing how a small group of TFSs from advanced economies and emerging Chinese players have been able to exercise different forms of bargaining and demonstrative power along the mining equipment GVCs. It also enabled an understanding of how they have been able to raise the bar for other mining equipment manufacturers, especially for those in developing countries, by establishing higher requirements for operating the chain. The promising perspectives of such a framework calls for the adoption of a much more eclectic approach to theory development that combines insights from different streams of the literature and disciplines within and beyond economics, including engineering and operation management.

181 For example, R&D, engineering consultancy, business services, maintenance, repairing and operating services, and vendor financial services.

On the methodological side, the original multi-methods research approach embraced in this thesis (and discussed in detail in Chapter 2) was particularly effective in providing new insights into different aspects of the multifaceted and complex phenomenon under analysis. A broader implication of this is that a greater combination of multiple methods within the economic discipline is desirable in order to tell different parts of the same story, and to offer a much more comprehensive picture of the subject matter of the research. However, such a research strategy, combining the extensive use of statistical and econometric techniques with mixed methods sectoral case studies and a significant qualitative component, is still extremely uncommon within the economic discipline. This is due to a number of interrelated factors which have to do with the marginalisation of alternative methods of enquiry in mainstream economics, the widespread perception within it that qualitative and mixed methods do not qualify as 'real' economics, the limited number of economic journals publishing results based on qualitative data, and the lack of training for economists at the graduate level in methods other than quantitative ones. This, in turn, calls for an in-depth reflection on what changes are needed in terms of norms, publishing processes and training content within the discipline in order to encourage the use and the integration of multiple methods.

6.3.2 Policy implications

The evidence presented in this thesis has significantly contributed to the debate about whether and how recent globalisation, particularly the rise of China, has shifted the goal posts for another G20 middle-income country such as South Africa. Chapters 3 to 5 have shown that China's increasing export and production capacity have substantially contributed to intensifying the challenges faced by South Africa's manufacturing industry, particularly in certain more advanced sectors. The evidence presented in Chapter 3 has pointed to the importance for firms of devoting substantial resources to the development and accumulation of capabilities. However, it has also underlined that investing in capital, technology and skills is not sufficient to counterbalance the negative impact of Chinese import penetration. Chapter 4 has shown that even in more technology-intensive sectors South African exporters are increasingly facing the competitive pressure of Chinese exports. Finally, the analysis conducted in Chapter 5 has revealed how, in one of these relatively more advanced manufacturing sectors, the growth prospects of South African firms and the effectiveness of their responses to increasing Chinese competition are constrained by a number of internal and external factors. More specifically, on one side, the firms often lack those capabilities and resources, complementary to the core technological ones, needed to enhance industrial scale-up, commercialisation and appropriability; to effectively manage product variety, supply chain and operational after-sales services; to secure affordable funding; and to offer competitive vendor financing packages to their clients. On the other side, they are not effectively supported by the broader South African industrial ecosystem and by targeted government interventions.

From a policy perspective, these results underline the urgency for the country to promote targeted strategies focused on developing its local production systems, by strengthening the capabilities of South Africa-based firms, specifically those domestically owned, and by removing the external obstacles constraining their further development. The building of integrated supply chains in the domestic economy constitutes an essential basis for the country's sustained industrial and productivity growth. Therefore, policies aimed at liberalising imports and attracting multinationals in specific sectors must be fully co-ordinated with other measures that support industrialisation and the development of national champions. This is particularly important in a number of relatively more technology-intensive sectors where many South African companies have already built an advanced base of core technical knowledge and expertise to enter and survive in global industries, and are in a transition process towards competing at the global technological frontier. These considerations call for the government to take an active role in developing, implementing and enforcing a wide array of policy measures aimed at fostering the accumulation and the integration of increasingly advanced capabilities by firms operating in South Africa, and, at the same time, at removing the binding constraints limiting their development, upgrading and value capture potential.

Irrespective of the specific sector under analysis, these policy measures should focus at least on the following three priority areas of policy intervention, which have been identified through extensive desk and field research in the country. First, to seize the opportunities for upgrading and value capture along GVCs, South African firms need substantial support in key technological and product services. In this respect, it is important to promote the development of public technology intermediaries to address the challenge of scaling up national OEMs and their suppliers and to promote collaboration across domestic and foreign players. Second, the lack of skills in many sectors represents another key binding constraint for firms' growth. Targeted policy initiatives and collaborative efforts between industry, government and academia are required to build sector-specific technical competences. The third key constraint faced by South African firms to be tackled is their limited ability to finance their current operations and new investments at internationally competitive rates. Policy interventions in this area should focus on the sectoral specificity and the affordability of the programs and solutions provided by development finance institutions.

However, these general guidelines should be translated into selective and targeted operational policy plans tailored to the specific needs of the sectors under analysis, as shown extensively in Chapter 5, where a number of specific policy measures have been identified for the mining equipment industry. This implies that an in-depth preliminary study of the state and future prospects of the sectoral value chains of interests is fundamental to identify windows of opportunity and to be able to design effective policy actions to seize them. On the one hand, these opportunities should be assessed in light of global and national sector-specific evidence and emerging dynamics. On the other hand, the design process of these policy actions should be supported by an analysis and a critical discussion of the lessons learned from other international experiences. Furthermore, the proposed industrial policy package should be feasible, implementable, enforceable in the specific country context and well-coordinated with its broader macroeconomic, education, trade and infrastructure strategies (Tregenna, 2011b; Andreoni and Tregenna, 2020). This means that such policies should be consistent with the internal power balances and the existing institutional and policy setting of the country. This is exactly the approach to the design of policy measures adopted in a recent background paper prepared for the South African Mining Equipment Master Plan (Andreoni and Torreggiani, 2020), which, in turn, is extensively based on the research conducted in Chapter 5.

The development of policy plans of this kind, built on in-depth firm and sectoral analyses, and factoring in the evolving global competitive landscape, is an important contribution to South African efforts to defy its comparative advantage in natural resources industries and diversify its economy towards higher value added activities, and more employment-absorbing and more sophisticated sectors.

6.4 Limitations, emerging issues and avenues for future research

The main limitations pertaining to the analyses conducted in Chapters 3 to 5 have already been discussed extensively in the corresponding final sections of these studies, together with a number of possible ways forward for future research. This section provides a more general discussion around the two main limitations of this thesis as a whole.

First, this thesis has focused on a specific set of trade- and GVC-related impacts of the rise of China, among those identified in Section 1.2.2 of Chapter 1. In particular, the potential direct complementary effect of China on South Africa, given by the fact that the former represents a large and fast-growing market for a variety of different products, has not been taken into account in this work.

China, indeed, is a huge consumer of intermediates, but also final goods such as cars and industrial machines, in which South Africa has built some distinctive capabilities. In-depth analyses of these sectors in China might help to identify a number of industrial niches and segments in which South African producers might enter and gain market shares.

However, and most importantly, China is also the largest consumer in the world of mineral resources and products, for which South Africa is a leading global producer and exporter. An interesting extension in this sense might be represented by an analysis along the lines of the one conducted by Teng and Lo (2019). They showed that the absolute gains from trade with China had a positive impact on export upgrading in selected low-income, resource-rich economies, largely through an increase in productive domestic investments. In that regard, one could ask whether the substantial revenues originating from the massive improvement in net barter terms of trade in South Africa with respect to China during the latest commodity boom have been channelled into productive investments or not, and whether they have contributed to boosting the potential for industrial development in the country.

As a second limitation, it is worth mentioning the fact that this thesis could not take into account a number of recent trends affecting the global trade and investment landscape that emerged during the active research process, between late 2017 and late 2020. In particular, the trade war between the United States and China over the 2018-2019 period, the outbreak of the COVID-19 pandemic, and the 'dual circulation' strategy in economic policy recently launched by the Chinese government, might have affected, and may still affect in the near future, some of the dynamics described in this thesis. These are briefly discussed in the following sub-sections, together with a number of related possible directions for future research.

6.4.1 The trade war between the United States and China

In early May 2018, the South African Department of Trade and Industry warned that South Africa could suffer collateral damage as a result of the trade tensions between the United States and China (Bloomberg, 2019). Concerns were raised on the impact of a trade war between these key global economies on South Africa's exports to both China and the United States, which in 2018 accounted for around 16% and 6.5% of the country's total exports (UNCTAD, 2020). What is certain is that South Africa was not particularly favoured by the tariffs imposed by the United States. Specifically, the Trump administration's decision to exclude South Africa from a list of countries exempted from tariffs imposed on steel and aluminium imports (i.e., 25% and 10%, respectively) was seen as a key factor exacerbating the competitiveness issues for this sector in South Africa, which was already suffering from import competition and global steel overcapacity (see also Chapters 3 to 5 on this). These concerns were shared by a number of industry experts and policy officers during the interviews conducted in South Africa in 2019 and used in Chapter 5 (Interviews 019078, 062002, 062189 and 062765).

In fact, by 2019, the imposition of duties might have contributed to the decline in productive capacity and employment trends observed in the basic iron and steel sector (Quantec, 2020). Furthermore, these measures might also have led to the decreasing volumes of exports to the United States registered in the same sector in 2019 (Quantec, 2020). As underlined by trade experts, these tariffs might have displaced South African iron and aluminium products shipped to the United States in favour of exempted countries like Australia, Brazil and South Korea (Engineering News, 2018; IDC, 2018). A key concern is also that these negative effects might last for a number of years given the prolonged uncertainty that will presumably characterise the relations between the United States and China in the near future. In fact, according to policy experts, the election of Biden as American president will result in a significant departure from the tone and style adopted by Trump when negotiating with China, at least in the short run. However, the tough positions adopted by the former administration leave very little political flexibility for the newly elected president and thus, in the near future, there is likely to be a period of continuing uncertainty with respect to the trade relations between the United States and China (The New York Times, 2020).

Building on these considerations, a promising direction for further research might be represented by an in-depth analysis of the South African production, employment and export trends in the steel and aluminium industries, and in related sectors, after the impositions of the tariffs and over the next few years. These tensions, together with the prolonged uncertainty, might significantly contribute to worsening the competitive position of these upstream segments of the metal-machinery value chains, and may also have, in turn, a negative impact on downstream domestic sectors like general and special purpose machinery.

6.4.2 The COVID-19 pandemic

The recent global pandemic has accelerated a contraction in international trade that was already occurring due to the tendency towards the reshoring of industrial activities in advanced economies over the past few years (ILO, 2020) and the rising geopolitical tensions between the key global economic powers mentioned in Section 6.4.1. The COVID-19 crisis has also led to a sharp decline in global FDI, with particular reference to inflows into developing countries (IMF, 2020). It has been stressed that the disruptive changes in the length, location and governance structure of GVCs following the COVID-19 crisis might give rise to additional structural transformation challenges for emerging economies (De Nicola et al., 2020). However, these might also present new opportunities for pursuing more inclusive and sustainable pathways of development and industrial catch-up (Seric and Hauge, 2020). In particular, reduced opportunities for export- and FDI-led industrialisation due to the reshoring of production and new trade regimes suggest the importance of imagining alternative industrialisation models. These could provide frameworks for countries to diversify their production base by leveraging existing domestic markets and creating new ones through forwards and backwards integration (Andreoni et al., 2021b).

In light of the current and expected trade disruption, South Africa's rich mineral deposits, as well as the country's proximity to other equally resource-rich economies in sub-Saharan Africa, might open up important opportunities for both upstream and downstream integration, as well as value addition through industrial and technological innovation. In what follows, I briefly reflect on the potential implications of these disruptions for the backwards-linked (upstream) mining equipment industry, which was the focus of Chapter 5.[182]

The impact of the COVID-19 crisis across different geographies has put new pressure on traditional mining global supply-chain structures, which are concentrated around a few equipment vendors from the United States, Europe, Japan and China. According to a recent exploratory analysis conducted by international professional services organisations (Ernst & Young, 2020), mining companies are actively exploring alternative and broader sources of supply to reduce reliance on a small number of overseas vendors. On the one hand, this might open up opportunities for local or regional companies with the right level of technology and production capabilities to enter into such value chains. On the other hand, foreign multinationals supplying mining equipment and other critical inputs to mining houses might decide to progressively relocate part of their production activities closer to their clients' operations, through subsidiaries or collaborative partnerships with local companies.

[182] An extended version of these considerations, also applied to the South African automotive sector, was published as part of a chapter I co-authored for a volume entitled *Structural Transformation in South Africa: the challenges of inclusive industrial development in a middle-income country* (Andreoni et al., 2021b).

The South African mining equipment sector is well positioned to seize both these opportunities in the domestic and regional mining markets. Obviously, strategic industrial policy actions will be needed to put conditions in place to attract and retain productive investments, and to help domestic mining equipment producers in their attempt to enter supply chains led by major mining companies. In this respect, the unprecedented pandemic crisis has made an institutional effort to reform local content and procurement policies in the South African mining sector, and to establish an efficient and affordable support system for export development of domestic equipment suppliers, even more urgent (Andreoni and Torreggiani, 2020; see also Chapter 5 on this). These considerations might serve as a starting point for an extension of the analysis conducted in Chapter 5, taking into account the impact of the COVID-19 crisis on the changes in terms of length, location and governance structure of the MGVC.

6.4.3 China's 'dual circulation' strategy

The so-called 'dual circulation' strategy was mentioned for the first time at a meeting of the Politburo of the Chinese Communist Party in May 2020. While official details on the practical contents of this new Chinese approach to economic policy are still sparse and contradictory, it will probably represent a core component of the 14th Five Year Plan, to be released in March 2021, and it will underpin China's future growth model (ODI, 2020). According to many analysts, this plan constitutes the Chinese strategic response to an increasingly hostile and unstable global landscape (see Sections 6.4.1 and 6.4.2 above), but it also follows China's long-standing objective of rebalancing its economy. Analysts expect that through this policy China will place a greater focus on domestic production and consumption markets (i.e., internal circulation), with the aim of building up self-reliant, more resilient and easily controllable supply chains (The Economist, 2020). However, so far, in an attempt to reassure its trading and investment partners about its sustained commitment to globalisation (i.e., external or international circulation), the Chinese government has strongly objected to these views (China People's Daily, 2020a and 2020b; ODI, 2020).

Thus, the main unanswered question is what this new policy orientation will consist of and how it will be implemented. This, in turn, will have an impact on the reconfiguration of China's participation patterns in the global trade and investment landscape and is likely to create new winners and losers among the countries engaging with China. Over the coming months and years, a careful monitoring of the developments in China's economic policy is particularly important for a country like South Africa, where the measures adopted within the context of this new 'dual circulation' strategy might further reinforce or even reverse some of the dynamics analysed in this thesis, opening up the way for new challenges and windows of opportunities. This is, indeed, a promising avenue for future research, analyses and scenario building that might also contribute to helping South African policymakers formulate appropriate and integrated responses to shape the strategic engagement of the country with its largest trading partner, China.

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Appendix A – Appendix to Chapter 3

Table A.1. Breakdown of industries depending on their technological classification.

Code	Description	Technology class
301	Meat, fish, fruit, etc.	
302	Dairy products	
303	Grain mill products, animal feeds	
304	Other food products	
305	Beverages	
321	Sawmilling, planing of wood	*Resource-based*
322	Wood, wood products	
323	Paper, paper products	
331/2	Coke oven, petroleum products	
337	Rubber products	
341	Glass, glass products	
342	Non-metallic mineral products	
311	Spinning, weaving of textiles	
312	Other textiles	
313	Knitted, crocheted fabrics	
314/5	Clothing	
316	Leather, leather products	
317	Footwear	*Low-tech*
324/5/6	Publishing, printing	
354	Structural steel products	
355	Other fabricated metal products	
391	Furniture	
392	Other manufacturing	
334	Basic chemicals	
335/6	Other chemicals	
338	Plastic products	
351	Basic iron, steel	
352	Non-ferrous metals	
356/9	General-purpose machinery	
357	Special-purpose machinery	
358	Household appliances	
361/2	Electrical equip., apparatus	
363	Insulated wire, cable	*Medium- to high-tech*
364	Accumulators, batteries	
365	Electric lamps, lighting equip.	
366	Other electrical equipment	
371/2/3	TV, radio, other electronic equip.	
374/5/6	Medical, measuring, controlling equip.	
381	Motor vehicles	
382	Bodies for motor vehicles	
383	Parts, accessories for motor vehicles	
384/5/6/7	Other transport equipment	

Source: Author's, based on Lall (2000).

Table A.2. Percentage of China's imports in total South African imports and domestic consumption, 2010–17.

Code	Description	% of China in total SA imports		% of Chinese import penetration	
		2010	2017	2010	2017
	Resource-based				
301	Meat, fish, fruit, etc.	3.19	5.77	0.79	1.18
302	Dairy products	0.79	0.94	0.04	0.06
303	Grain mill prod., animal feeds	3.79	3.79	0.38	0.53
304	Other food products	2.60	2.20	0.24	0.30
305	Beverages	0.17	0.24	0.01	0.01
321	Sawmilling, planing of wood	4.63	2.96	0.85	0.57
322	Wood, wood products	24.11	25.61	2.12	3.27
323	Paper, paper products	8.30	12.80	1.37	2.74
331/2	Coke oven, petroleum products	2.81	4.22	0.85	1.62
337	Rubber products	23.03	26.97	10.78	15.00
341	Glass, glass products	37.76	37.91	8.38	10.28
342	Non-metallic mineral products	24.79	31.98	3.61	5.79
	Low-tech				
311	Spinning, weaving of textiles	42.48	45.73	18.50	24.42
312	Other textiles	36.96	36.47	8.23	15.52
313	Knitted, crocheted fabrics	58.20	52.76	31.50	44.69
314/5	Clothing	61.52	58.94	25.56	29.69
316	Leather, leather products	47.75	58.07	18.56	29.69
317	Footwear	73.79	60.98	48.94	47.63
324/5/6	Publishing, printing, rel. serv.	18.48	13.92	1.30	1.91
354	Structural steel products	12.92	30.56	0.86	2.02
355	Other fabricated metal products	31.74	37.59	6.43	9.02
391	Furniture	47.52	45.08	18.23	15.39
392	Other manufacturing	47.81	43.15	7.74	8.89
	Medium- to high-tech				
334	Basic chemicals	11.31	18.82	5.09	9.71
335/6	Other chemicals	6.11	7.57	2.47	3.51
338	Plastic products	21.69	25.31	3.25	5.88
351	Basic iron, steel	16.26	31.11	3.38	7.75
352	Non-ferrous metals	9.22	13.18	2.32	3.40
356/9	General-purpose machinery	25.62	37.36	23.83	39.96
357	Special-purpose machinery	10.92	18.51	6.20	11.25
358	Household appliance	61.62	62.79	21.21	25.41
361/2	Electrical equip., apparatus	17.60	28.50	9.52	19.56
363	Insulated wire, cable	23.65	37.13	4.40	9.58
364	Accumulators, batteries	27.62	43.40	11.44	23.99
365	Electric lamps, lighting equip.	59.10	64.94	31.33	37.80
366	Other electrical equipment	16.82	26.46	4.43	11.03
371/2/3	TV, radio, other electronic equip.	35.67	66.42	30.95	51.14
374/5/6	Medical, measuring, controlling equip.	9.51	14.86	7.88	14.10
381	Motor vehicles	2.97	1.64	1.48	1.02
382	Bodies for motor vehicles	32.06	30.12	3.47	5.24
383	Parts, accessories for motor vehicles	8.53	13.33	1.61	3.04
384/5/6/7	Other transport equipment	3.20	10.38	1.38	5.10
–	Total	17.77	22.47	5.26	8.30

Source: Own calculations using UN Comtrade (2018) and Statistics South Africa (2018b) data.

Table A.3. South Africa's low-wage trade partners (i.e., imports) from 2010 to 2017 (excluding China).

Afghanistan	Ethiopia	Nicaragua
Albania	Fiji	Niger
Algeria	Gambia	Nigeria
Angola	Georgia	Pakistan
Armenia	Ghana	Papua New Guinea
Azerbaijan	Guatemala	Paraguay
Bangladesh	Guinea	Peru
Belarus	Guyana	Philippines
Belize	Haiti	Rep. of Moldova
Benin	Honduras	Rwanda
Bhutan	India	St. Vincent & the Grenadines
Bolivia	Indonesia	Samoa
Bosnia Herzegovina	Iran	Sao Tome and Principe
Botswana	Iraq	Senegal
Bulgaria	Jamaica	Serbia
Burkina Faso	Jordan	Sierra Leone
Burundi	Kenya	Solomon Islands
Cape Verde	Kiribati	Sri Lanka
Cambodia	Kyrgyzstan	Swaziland
Cameroon	Lao People's Dem. Rep.	Tajikistan
Central African Republic	Lesotho	Thailand
Chad	Liberia	Timor-Leste
Colombia	Macedonia	Togo
Comoros	Madagascar	Tonga
Congo	Malawi	Tunisia
Cuba	Mali	Turkmenistan
Cote d'Ivoire	Marshall Islands	Uganda
Dem. Rep. of the Congo	Mauritania	Ukraine
Djibouti	Mongolia	United Rep. of Tanzania
Dominica	Morocco	Uzbekistan
Dominican Republic	Mozambique	Vietnam
Ecuador	Myanmar	Yemen
Egypt	Namibia	Zambia
El Salvador	Nepal	Zimbabwe

Source: Author's calculations based on constant GDP per capita (US$2010) from the World Bank Indicators Dataset (2018).

Table A.4. % of firms investing in capabilities and investment intensity by sector, 2010–2017 (averages).

Code	Description	Capital investments		R&D expenditures		Training expenditures	
		%	ints. (%)	%	ints. (%)	%	ints. (%)
	Resource-based						
301	Meat, fish, fruit, etc.	68	5.4	5	0.12	14	0.04
302	Dairy products	71	6.4	6	0.41	16	0.11
303	Grain mill prod., animal feeds	66	5.0	9	0.15	17	0.32
304	Other food products	68	5.0	6	0.30	15	0.07
305	Beverages	68	14.0	7	0.75	19	0.92
321	Sawmilling, planing of wood	68	6.8	2	0.07	11	0.01
322	Wood, wood products	60	4.5	2	0.04	5	0.02
323	Paper, paper products	66	5.5	5	0.05	12	0.09
331/2	Coke oven, petroleum products	62	4.4	9	0.11	21	0.49
337	Rubber products	63	4.8	5	0.13	10	0.16
341	Glass, glass products	69	5.5	6	0.10	10	0.03
342	Non-metallic mineral products	65	6.5	7	0.14	13	0.05
	Low-tech						
311	Spinning, weaving of textiles	60	5.4	3	0.09	8	0.02
312	Other textiles	61	4.3	3	0.06	7	0.01
313	Knitted, crocheted fabrics	58	5.4	1	0.02	7	0.01
314/5	Clothing	59	3.4	5	0.07	5	0.01
316	Leather, leather products	59	3.9	2	0.04	7	0.01
317	Footwear	61	3.0	5	0.16	9	0.01
324/5/6	Publishing, printing, rel. serv.	64	6.4	1	0.08	6	0.01
354	Structural steel products	64	5.0	2	0.02	9	0.03
355	Other fabricated metal products	64	5.5	4	0.06	10	0.10
391	Furniture	60	4.2	1	0.03	5	0.01
392	Other manufacturing	62	5.0	4	0.11	8	0.05
	Medium- to high-tech						
334	Basic chemicals	66	4.3	8	0.12	16	0.02
335/6	Other chemicals	68	4.5	11	0.36	16	0.26
338	Plastic products	66	5.8	3	0.08	11	0.06
351	Basic iron, steel	63	5.2	2	0.07	10	0.07
352	Non-ferrous metals	64	4.8	2	0.02	11	0.01
356/9	General-purpose machinery	67	4.6	4	0.10	11	0.04
357	Special-purpose machinery	68	4.8	10	0.14	13	0.02
358	Household appliance	71	3.6	6	0.04	20	0.02
361/2	Electrical equip., apparatus	70	4.1	4	0.10	14	0.13
363	Insulated wire, cable	70	3.7	5	0.09	17	0.41
364	Accumulators, batteries	77	3.3	10	0.02	20	0.05
365	Electric lamps, lighting equip.	62	2.4	3	0.02	12	0.01
366	Other electrical equipment	66	3.8	3	0.27	10	0.05
371/2/3	TV, radio, other electronic equip.	68	4.2	4	0.31	10	0.06
374/5/6	Medical, measuring, controlling equip.	69	4.6	11	0.72	11	0.03
381	Motor vehicles	57	6.2	11	0.30	16	0.01
382	Bodies for motor vehicles	65	3.9	4	0.01	13	0.02
383	Parts, accessories for motor vehicles	67	4.7	14	0.47	22	0.04
384/5/6/7	Other transport equipment	64	4.4	5	0.20	16	0.08
–	Total	64	5.1	5	0.13	10	0.08

Source: Own calculations using SARS data.

Table A.5. Average % of firms investing in capabilities, average intensity of investments by size, 2010–2017.

Description	Capital investments		R&D expenditures		Training expenditures	
	%	ints. (%)	%	ints. (%)	%	ints. (%)
Very small	57	5.1	1	0.09	3	0.06
Small	73	4.8	5	0.12	15	0.08
Medium	77	5.0	13	0.20	31	0.14
Large	79	5.3	34	0.50	45	0.30
Total	64	5.1	5	0.13	10	0.08

Notes: Size is defined with respect to firms' full-time equivalent employment according to the cut-off published by the DTI (2016). Firms are defined as very small (or micro) when employing fewer than 21 people, small and medium when employing 21–50 and 51–200 people, respectively, and large when employing more than 200 workers.
Source: Own calculations using SARS data and company size classifications provided by the DTI (2016).

Table A.6. Indirect import competition analysis: employment growth.

Dep. variable	$\Delta\log(E)_{i,s}^{t,t+1}$				
Specification	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	OLS	OLS	OLS
A. First-order indirect import exposure variables					
$PEN_{s,t}^{CHN}$	–0.629** (0.269)	–0.629** (0.269)	–0.537** (0.266)		
$PEN_{s,t}^{CHN,UP}$	–2.213*** (0.541)		–2.187*** (0.541)		
$PEN_{s,t}^{CHN,DOWN}$		–0.087 (0.639)	–0.796 (0.639)		
$PEN_{s,t}^{CHN} + PEN_{s,t}^{CHN,UP}$				–1.138*** (0.340)	–1.262*** (0.341)
$\times (d)\ INVST_{i,t}$					0.193*** (0.015)
$\times (d)\ R\&D_{i,t}$					0.102*** (0.037)
$\times (d)\ TRAIN_{i,t}$					0.117*** (0.024)
R-squared	0.3385	0.3370	0.3385	0.3387	0.3388
B. Full (higher-order) indirect import exposure variables					
$PEN_{s,t}^{CHN}$	–0.702** (0.274)	–0.702** (0.274)	–0.623*** (0.271)		
$PEN_{s,t}^{CHN,UP}$	–1.757*** (0.430)		–1.755*** (0.430)		
$PEN_{s,t}^{CHN,DOWN}$		–0.075 (0.552)	–0.745 (0.552)		
$PEN_{s,t}^{CHN} + PEN_{s,t}^{CHN,UP}$				–1.097*** (0.328)	–1.211*** (0.239)
$\times (d)\ INVST_{i,t}$					0.151*** (0.017)
$\times (d)\ R\&D_{i,t}$					0.101*** (0.039)
$\times (d)\ TRAIN_{i,t}$					0.077*** (0.023)
R-squared	0.3382	0.3368	0.3383	0.3387	0.3388
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Observations	90,530	90,530	90,530	90,530	90,530
Number of firms	12,959	12,959	12,959	12,959	12,959

Notes:

1. Dependent variables are log difference of firm employment between year t and t + 1.
2. All specifications refer to surviving firms and include the constant and all controls used in previous estimates.
3. Standard errors in parentheses are clustered at both industry and firm level.

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***} p < 0.01$

Source: Author's calculations using SARS data.

Table A.7. Indirect import competition analysis: sales growth and firm exit.

Dep. Variable	$\Delta\log(S)_{i,s}^{t,t+1}$	$\Delta\log(S)_{i,s}^{t,t+1}$	$Death_{i,s}^{t,t+1}$	$Death_{i,s}^{t,t+1}$
Specification	(1)	(2)	(3)	(4)
Estimation method	OLS	OLS	OLS	OLS
A. First-order indirect import exposure variables				
$PEN_{s,t}^{CHN} + PEN_{s,t}^{CHN,UP}$	–0.901***	–0.978***	0.125	0.233**
	(0.276)	(0.278)	(0.167)	(0.100)
$\times (d)\ INVST_{i,t}$		0.037***		–0.142***
		(0.019)		(0.009)
$\times (d)\ R\&D_{i,t}$		0.101***		–0.021**
		(0.042)		(0.013)
$\times (d)\ TRAIN_{i,t}$		0.036		–0.142***
		(0.028)		(0.010)
R-squared	0.2103	0.2104	0.0757	0.0759
B. Full (higher-order) indirect import exposure variables				
$PEN_{s,t}^{CHN} + PEN_{s,t}^{CHN,UP}$	–0.967***	–0.992***	0.128	0.215**
	(0.278)	(0.279)	(0.171)	(0.098)
$\times (d)\ INVST_{i,t}$		0.035***		–0.138***
		(0.019)		(0.009)
$\times (d)\ R\&D_{i,t}$		0.100***		–0.020**
		(0.043)		(0.012)
$\times (d)\ TRAIN_{i,t}$		0.035		–0.139***
		(0.029)		(0.009)
R-squared	0.2104	0.2104	0.0758	0.0759
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Observations	86,289	86,289	129,695	129,695
Number of firms	12,919	12,919	22,785	22,785

Notes:

1. Dependent variables in (1) and (2) is the log difference of firm sales between year t and t + 1.
2. Dependent variables in (3) and (4) is a dummy indicating firm death in year t + 1.
3. A linear probability model is used in (3) and (4).
4. Estimates in (1) and (2) refer to the subset of surviving firms.
5. All specifications include the constant and all controls used in previous estimates.
6. All specifications report OLS estimates.
7. Standard errors in parentheses are clustered at both industry and firm level.

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}p < 0.01$

Source: Author's calculations using SARS data.

Table A.8. Indirect import competition analysis: (a) sales growth and (b) firm exit.

(a)

Dep. variable	$\Delta\log(S)_{i,s}^{t,t+1}$		
Specification	(1)	(2)	(3)
Estimation method	IV	IV	IV
$PEN_{s,t}^{CHN}$	–0.997***	–1.181***	–1.135***
	(0.331)	(0.382)	(0.383)
$PEN_{s,t}^{CHN,UP}$	–2.212***		–2.362***
	(0.634)		(0.630)
$PEN_{s,t}^{CHN,DOWN}$		–0.098	–0.743
		(0.552)	(0.581)
First-stage F-stat.	589.69	525.16	419.03
R-squared	0.2087	0.2079	0.2089
Firm fixed effects	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Observations	86,289	86,289	86,289
Number of firms	12,919	12,919	12,919

(b)

Dep. variable	$Death_{i,s}^{t,t+1}$		
Specification	(1)	(2)	(3)
Estimation method	IV	IV	IV
$PEN_{s,t}^{CHN}$	0.148	0.157	0.153
	(0.168)	(0.169)	(0.171)
$PEN_{s,t}^{CHN,UP}$	0.202		0.245
	(0.181)		(0.179)
$PEN_{s,t}^{CHN,DOWN}$		0.201	0.387
		(0.489)	(0.554)
First-stage F-stat.	533.12	509.78	528.67
R-squared	0.0722	0.0721	0.0724
Firm fixed effects	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Observations	129,695	129,695	129,695
Number of firms	22,785	22,785	22,785

Notes:
1. Dependent variable in (a) is log difference of firm sales between year t and t + 1.
2. Dependent variable in (b) is a dummy indicating firm death in year t + 1.
3. A linear probability model is used in (b); estimates in (a) refer to the subset of surviving firms.
4. All specifications include the constant and all controls used in previous estimates.
5. All specifications are based on first-order indirect import exposure variables.
6. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in all columns.
7. Standard errors in parentheses are clustered at both the industry and firm level.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Own calculations using SARS data.

Table A.9. Direct import competition analysis on the full sample: employment and sales growth.

Dep. variable	$\Delta\log(E)_{i,s}^{t,t+1}$	$\Delta\log(E)_{i,s}^{t,t+1}$	$\Delta\log(S)_{i,s}^{t,t+1}$	$\Delta\log(S)_{i,s}^{t,t+1}$
Specification	(1)	(2)	(3)	(4)
Estimation method	IV	IV	IV	IV
Controls				
$\log(E)_{i,t}$	–0.424***	–0.427***	–0.370***	–0.371***
	(0.005)	(0.005)	(0.007)	(0.007)
$\log(Age)_{i,t}$	0.065***	0.067***	0.056***	0.058***
	(0.012)	(0.012)	(0.012)	(0.012)
$INVST_{i,t}$	0.003***	0.003***	0.001***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)
$R\&D_{i,t}$	0.001***	0.001***	0.003	0.003
	(0.001)	(0.001)	(0.002)	(0.002)
$TRAIN_{i,t}$	–0.001	–0.001	–0.001	–0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Import exposure variables				
$PEN_{s,t}^{CHN}$	–1.347***	–1.495***	–1.533***	–1.556***
	(0.389)	(0.390)	(0.394)	(0.395)
$\times (d)\ INVST_{i,t}$		0.215***		0.246***
		(0.021)		(0.020)
$\times (d)\ R\&D_{i,t}$		0.173**		0.124**
		(0.053)		(0.051)
$\times (d)\ TRAIN_{i,t}$		0.224**		0.057
		(0.035)		(0.036)
Constant	1.300***	1.318***	6.048***	6.061***
	(0.044)	(0.044)	(0.113)	(0.115)
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
First-stage *F*-stat.	697.55	605.21	671.74	591.86
Observations	129,695	129,695	128,341	128,341
R-squared	0.3435	0.3441	0.2350	0.2351
Number of firms	22,785	22,785	22,344	22,344

Notes:
1. Dependent variable in (1) and (2) is the log difference of firm employment between year t and t + 1.
2. Dependent variable in (3) and (4) is the log difference of firm sales between year t and t + 1.
3. All estimates refer to the full sample of both surviving and dying firms.
4. All specifications report IV estimates.
5. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in all columns.
6. Standard errors in parentheses are clustered at both industry and firm level.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Author's calculations using SARS data.

Table A.10. Direct import competition analysis with province dummies: firms' growth and survival.

Dep. variable	$\Delta\log(E)_{i,s}^{t,t+1}$	$\Delta\log(S)_{i,s}^{t,t+1}$	$Death_{i,s}^{t,t+1}$
Specification	(1)	(2)	(3)
Estimation method	IV	IV	IV
Controls			
$\log(E)_{i,t}$	–0.396***	–0.365***	–0.052***
	(0.006)	(0.010)	(0.002)
$\log(Age)_{i,t}$	0.073***	0.059***	0.133***
	(0.014)	(0.014)	(0.006)
$INVST_{i,t}$	0.004***	0.001***	–0.002***
	(0.002)	(0.001)	(0.001)
$R\&D_{i,t}$	0.001***	0.003	–0.001
	(0.001)	(0.002)	(0.001)
$TRAIN_{i,t}$	–0.001	–0.001	–0.001
	(0.001)	(0.001)	(0.001)
Import exposure variables			
$PEN_{s,t}^{CHN}$	–1.484***	–1.397***	0.369**
	(0.401)	(0.416)	(0.180)
$\times (d)\ INVST_{i,t}$	0.231***	0.232***	–0.255***
	(0.023)	(0.025)	(0.012)
$\times (d)\ R\&D_{i,t}$	0.144**	0.122**	–0.037**
	(0.055)	(0.059)	(0.020)
$\times (d)\ TRAIN_{i,t}$	0.149**	0.054	–0.203***
	(0.034)	(0.038)	(0.015)
Constant	1.077***	5.878***	–0.204***
	(0.051)	(0.161)	(0.021)
Firm fixed effects	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Province dummies	Yes	Yes	Yes
First-stage *F*-stat.	562.69	546.04	521.15
Observations	90,530	86,289	129,695
R-squared	0.3163	0.2199	0.0754
Number of firms	12,959	12,919	22,785

Notes:
1. Dependent variable in (1) is the log difference of firm employment between year t and t + 1.
2. Dependent variable in (2) is the log difference of firm sales between year t and t + 1.
3. Dependent variable in (3) is a dummy indicating firm death in year t + 1.
4. Estimates in (1) and (2) refer to the subset of surviving firms.
5. A linear probability model is used in (3).
6. All specifications report IV estimates.
7. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in all columns.
8. Standard errors in parentheses are clustered at both industry and firm level.

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}p < 0.01$

Source: Author's calculations using SARS data.

Table A.11. Direct import competition analysis with $PEN_{s,t}^{LOW}$ and $PEN_{s,t}^{ROW}$: firms' growth and survival.

Dep. variable	$\Delta\log(E)_{i,s}^{t,t+1}$	$\Delta\log(S)_{i,s}^{t,t+1}$	$Death_{i,s}^{t,t+1}$
Specification	(1)	(2)	(3)
Estimation method	IV	IV	IV
Controls			
$\log(E)_{i,t}$	–0.394***	–0.363***	–0.052***
	(0.006)	(0.010)	(0.002)
$\log(Age)_{i,t}$	0.075***	0.059***	0.133***
	(0.014)	(0.014)	(0.006)
$INVST_{i,t}$	0.004***	0.001***	–0.002***
	(0.002)	(0.001)	(0.001)
$R\&D_{i,t}$	0.001***	0.003	–0.001
	(0.001)	(0.002)	(0.001)
$TRAIN_{i,t}$	–0.001	–0.001	–0.001
	(0.001)	(0.001)	(0.001)
Import exposure variables			
$PEN_{s,t}^{CHN}$	–1.228***	–1.259***	0.240
	(0.124)	(0.357)	(0.180)
$PEN_{s,t}^{LOW}$	–0.096	–0.071	0.002
	(0.118)	(0.116)	(0.058)
$PEN_{s,t}^{ROW}$	–0.332***	–0.388***	0.047
	(0.135)	(0.161)	(0.061)
Constant	1.058***	5.898***	–0.183***
	(0.049)	(0.161)	(0.026)
Firm fixed effects	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
First-stage F-stat.	568.12	552.75	537.05
Observations	90,530	86,289	129,695
R-squared	0.3170	0.2210	0.0735
Number of firms	12,959	12,919	22,785

Notes:
1. Dependent variable in (1) is the log difference of firm employment between year t and t + 1.
2. Dependent variable in (2) is the log difference of firm sales between year t and t + 1.
3. Dependent variable in (3) is a dummy indicating firm death in year t + 1.
4. A linear probability model is used in (3).
5. Estimates in (1) and (2) refer to the subset of surviving firms.
6. All specifications report IV estimates.
7. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in all columns.
8. Standard errors in parentheses are clustered at both industry and firm level.

$^{*} p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$

Source: Author's calculations using SARS data.

Table A.12. Direct import competition analysis, using $ROYAL_{i,t}$ in place of $R\&D_{i,t}$.

Dep. variable	$\Delta\log(E)_{i,s}^{t,t+1}$	$\Delta\log(S)_{i,s}^{t,t+1}$	$Death_{i,s}^{t,t+1}$
Specification	(1)	(2)	(3)
Estimation method	IV	IV	IV
Controls			
$\log(E)_{i,t}$	–0.396***	–0.364***	–0.052***
	(0.006)	(0.010)	(0.002)
$\log(Age)_{i,t}$	0.073***	0.059***	0.133***
	(0.014)	(0.014)	(0.006)
$INVST_{i,t}$	0.004***	0.001***	–0.002***
	(0.002)	(0.001)	(0.001)
$ROYAL_{i,t}$	0.002	0.005	–0.001
	(0.004)	(0.004)	(0.004)
$TRAIN_{i,t}$	–0.001	–0.001	–0.001
	(0.001)	(0.001)	(0.001)
Import exposure variables			
$PEN_{s,t}^{CHN}$	–1.482***	–1.404***	0.368**
	(0.401)	(0.415)	(0.181)
$\times (d)\ INVST_{i,t}$	0.231***	0.233***	–0.254***
	(0.023)	(0.022)	(0.011)
$\times (d)\ ROYAL_{i,t}$	0.115*	0.065	–0.036
	(0.068)	(0.089)	(0.070)
$\times (d)\ TRAIN_{i,t}$	0.152***	0.042	–0.202***
	(0.034)	(0.037)	(0.014)
Constant	1.065***	5.858***	–0.198***
	(0.036)	(0.159)	(0.020)
Firm fixed effects	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
First-stage *F*-stat.	564.15	541.01	507.43
Observations	90,530	86,289	129,695
R-squared	0.3162	0.2195	0.0753
Number of firms	12,959	12,919	22,785

Notes:

1. Dependent variable in (1) is the log difference of firm employment between year t and t + 1.
2. Dependent variable in (2) is the log difference of firm sales between year t and t + 1.
3. Dependent variable in (3) is a dummy indicating firm death in year t + 1.
4. A linear probability model is used in (3).
5. Estimates in (1) and (2) refer to the subset of surviving firms.
6. All specifications report IV estimates.
7. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in all columns.
8. A proxy of external product innovation is used in all specifications (i.e., $ROYAL_{i,t}$ in place of $R\&D_{i,t}$).
9. Standard errors in parentheses are clustered at both industry and firm level.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Author's calculations using SARS data.

Table A.13. Direct import competition analysis, using $INNOV_{i,t}$ (i.e., $R\&D_{i,t}+ ROYAL_{i,t}$) in place of $R\&D_{i,t}$.

Dep. variable	$\Delta\log(E)_{i,s}^{t,t+1}$	$\Delta\log(S)_{i,s}^{t,t+1}$	$Death_{i,s}^{t,t+1}$
Specification	(1)	(2)	(3)
Estimation method	IV	IV	IV
Controls			
$\log(E)_{i,t}$	–0.396***	–0.364***	–0.052***
	(0.006)	(0.010)	(0.002)
$\log(Age)_{i,t}$	0.073***	0.059***	0.133***
	(0.014)	(0.014)	(0.006)
$INVST_{i,t}$	0.004***	0.001***	–0.002***
	(0.002)	(0.001)	(0.001)
$INNOV_{i,t}$	0.001***	0.001***	–0.001
	(0.001)	(0.001)	(0.001)
$TRAIN_{i,t}$	–0.001	–0.001	–0.001
	(0.001)	(0.001)	(0.001)
Import exposure variables			
$PEN_{s,t}^{CHN}$	–1.489***	–1.404***	0.370**
	(0.401)	(0.415)	(0.180)
$\times (d)\ INVST_{i,t}$	0.230***	0.232***	–0.255***
	(0.023)	(0.022)	(0.012)
$\times (d)\ INNOV_{i,t}$	0.134***	0.122***	–0.037**
	(0.055)	(0.059)	(0.020)
$\times (d)\ TRAIN_{i,t}$	0.149***	0.055	–0.206***
	(0.034)	(0.038)	(0.015)
Constant	1.064***	5.860***	–0.197***
	(0.036)	(0.158)	(0.020)
Firm fixed effects	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
First-stage F-stat.	581.98	557.87	535.16
Observations	90,530	86,289	129,695
R-squared	0.3162	0.2196	0.0753
Number of firms	12,959	12,919	22,785

Notes:
1. Dependent variable in (1) is the log difference of firm employment between year t and t + 1.
2. Dependent variable in (2) is the log difference of firm sales between year t and t + 1.
3. Dependent variable in (3) is a dummy indicating firm death in year t + 1.
4. A linear probability model is used in (3).
5. Estimates in (1) and (2) refer to the subset of surviving firms.
6. All specifications report IV estimates.
7. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in all columns.
8. A proxy of total product innovation is used in all specifications (i.e, $INNOV_{i,t}$ in place of $R\&D_{i,t}$).
9. Standard errors in parentheses are clustered at both industry and firm level.

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}p < 0.01$

Source: Author's calculations using SARS data.

Table A.14. Direct import competition analysis excluding consumer electronics sectors.

Dep. variable	$\Delta\log(E)_{i,s}^{t,t+1}$	$\Delta\log(S)_{i,s}^{t,t+1}$	$Death_{i,s}^{t,t+1}$
Specification	(1)	(2)	(3)
Estimation method	IV	IV	IV
Controls			
$\log(E)_{i,t}$	–0.392***	–0.363***	–0.050***
	(0.006)	(0.010)	(0.002)
$\log(Age)_{i,t}$	0.071***	0.063***	0.127***
	(0.014)	(0.014)	(0.006)
$INVST_{i,t}$	0.004***	0.001***	–0.002***
	(0.002)	(0.001)	(0.001)
$R\&D_{i,t}$	0.001***	0.003	–0.001
	(0.001)	(0.002)	(0.001)
$TRAIN_{i,t}$	–0.001	–0.001	–0.001
	(0.001)	(0.001)	(0.001)
Import exposure variables			
$PEN_{s,t}^{CHN}$	–1.501***	–1.404***	0.373**
	(0.415)	(0.422)	(0.182)
$\times (d)\ INVST_{i,t}$	0.243***	0.249***	–0.251***
	(0.026)	(0.029)	(0.015)
$\times (d)\ R\&D_{i,t}$	0.161**	0.135**	–0.035**
	(0.057)	(0.061)	(0.022)
$\times (d)\ TRAIN_{i,t}$	0.153**	0.057	–0.197***
	(0.036)	(0.039)	(0.016)
Constant	1.102***	5.505***	–0.289***
	(0.053)	(0.168)	(0.025)
Firm fixed effects	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
First-stage F-stat.	559.34	537.11	535.52
Observations	88,986	83,172	126,415
R-squared	0.3130	0.2171	0.0730
Number of firms	12,738	12,626	22,507

Notes:

1. Dependent variable in (1) is the log difference of firm employment between year t and t + 1.
2. Dependent variable in (2) is the log difference of firm sales between year t and t + 1.
3. Dependent variable in (3) is a dummy indicating firm death in year t + 1.
4. A linear probability model is used in (3).
5. Estimates in (1) and (2) refer to the subset of surviving firms.
6. All specifications report IV estimates excluding consumer electronics' sectors from $PEN_{s,t}^{CHN}$.
7. Consumer electronics' sectors: 358, 364, 365, 372 (see Table A1).
8. China's import share in other LMICs is used as the instrument for $PEN_{s,t}^{CHN}$ in all columns.
9. Standard errors in parentheses are clustered at both industry and firm level.

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***} p < 0.01$

Source: Author's calculations using SARS data.

Appendix B – Appendix to Chapter 4

Table B.1. List of products in each medium- and high-technology sub-sector.

AUTOMOTIVE

SITC 781: Motor vehicles for the transport of persons; SITC 782: Motor vehicles for the transport of goods, special purpose; SITC 783: Road motor vehicles, n.e.s.; SITC 784: Parts and accessories of vehicles of 722, 781, 782, 783; SITC 785: Motorcycles and cycles. All sub-headings at the 6-digit product level included.

CHEMICALS

SITC 512: Alcohols, phenols, phenol-alcohols, and their halogenated, sulphonated, nitrated or nitrosated derivatives; SITC 513: Carboxylic acids and their anhydrides, halides, peroxides and peroxyacids; their halogenated, sulphonated, nitrated or nitrosated derivatives; SITC 533: Pigments, paints, varnished and related materials; SITC 553: Perfumery, cosmetics; SITC 554: Soaps, cleansing and polishing preparations.; SITC 562: Fertilizers (other than those of group 272); SITC 591: Insecticides, rodenticides, fungicides, herbicides, anti-sprouting products and plant-growth regulators, disinfectants and similar products, put up in forms or packings for retail sale or as preparations or articles (e.g., sulphur-treated bands, wicks and candles, and fly-papers); SITC 592: Starches, inulin and wheat gluten, albuminoidal substances, glues; SITC 593: Explosives and pyrotechnic products; SITC 597: Prepared additives for mineral oils and the like, prepared liquids for hydraulic transmission; anti-freezing preparations and prepared de-icing fluids; lubricating preparations; SITC 598: Miscellaneous chemical products, n.e.s. All sub-headings at the 6-digit product level included.

PLASTICS

SITC 571: Polymers of ethylene, in primary forms; SITC 572: Polymers of styrene, in primary forms ; SITC 573: Polymers of vinyl chloride or of other halogenated olefins, in primary forms; SITC 574: Polyacetals, other polyethers and epoxide resins, in primary forms; polycarbonates, alkyd resins, polyallyl esters and other polyesters, in primary forms; SITC 575: Other plastics, in primary forms; SITC 581: Tubes, pipes and hoses, and fittings therefor, of plastics; SITC 582: plates, sheets, film, foil and strip, of plastics; SITC 583: Monofilament of which any cross-sectional dimension exceeds 1mm, rods, sticks and profile shapes, whether or not surface-worked but not otherwise worked, of plastics. All sub-headings at the 6-digit product level included.

IRON AND STEEL

SITC 671: Pig-iron, spiegeleisen, sponge iron, iron or steel granules and powders and ferroalloys; SITC 672: Ingots and other primary forms, of iron or steel, semi-finished products of iron or steel; SITC 673: Flat-rolled products of iron or non-alloy steel, not clad, plated or coated; SITC 674: Flat-rolled products of iron or non-alloy steel, clad, plated or coated; SITC 675: Flat-rolled products of alloy steel ; SITC 676: Iron and steel bars, rods, angles, shapes and sections (including sheet piling); SITC 677: Rails or railway track construction material, of iron or steel; SITC 678: Wire of iron or steel; SITC 679: Tubes, pipes and hollow profiles, and tube or pipe fittings, of iron or steel. All sub-headings at the 6-digit product level included.

ENGINES AND MOTORS

SITC 711: Steam or other vapour-generating boilers, superheated water boilers, and auxiliary plant for use therewith, parts thereof; SITC 713: Internal combustion piston engines and parts thereof, n.e.s.; SITC 714: Engines and motors, non-electric (other than those of groups 712, 713, 718), parts, n.e.s. All sub-headings at the 6-digit product level included.

NON-ELECTRICAL MACHINERY

SITC 721: Agricultural machinery (excluding tractors), parts thereof; SITC 722: Tractors; SITC 723: Civil engineering, contractors' plant and equipment, parts thereof; SITC 724: Textile, leather machinery and parts thereof, n.e.s.; SITC 725: Paper mill, pulp mill machinery, paper-cutting machines, other machinery for manufacture of paper articles; parts thereof; SITC 726: Printing, bookbinding machinery and parts thereof; SITC 727: Food-processing machines (excluding domestic), parts thereof; SITC 728: Other specialised machinery, parts thereof, n.e.s.; SITC 731: Machine tools working by removing metal or other material; SITC 733: Machine tools for working metal, sintered metal carbides or cermets, without removing material; SITC 735: Parts, n.e.s., and accessories suitable for use solely or principally with the machines 731 and 733; SITC 737: Metalworking machinery (other than machine tools) and parts thereof, n.e.s.; SITC 741: Heating and cooling equipment and parts thereof, n.e.s.; SITC 742: Pumps for liquids, whether or not fitted with a measuring device, liquid elevators, parts for such pumps and liquid elevators; SITC 743: Pumps (other than pumps for liquids), air or other gas compressors and fans, ventilating or recycling hoods incorporating a fan, whether or not fitted with filters, centrifuges, filtering, purifying apparatus, parts thereof; SITC 744: Mechanical handling equipment, parts thereof, n.e.s.; SITC 745: Non-electrical machinery, tools and mechanical apparatus and parts thereof, n.e.s.; SITC 746: Ball- or roller-bearings; SITC 747: Taps, cocks, valves and similar appliances for pipes, boiler shells, tanks, vats or the like, including pressure-reducing valves and thermostatically controlled valves; SITC 748: Transmission shafts; SITC 749: Non-electrical parts and accessories of machinery, n.e.s. All sub-headings at the 6-digit product level included. SITC 72: Special purpose machinery; SITC 73: Metalworking machinery, machine tools; SITC 74: General purpose machinery; SITC 723.4: Mining machinery (machinery used exclusively in the construction industry have been excluded when possible).

HOUSEHOLD APPLIANCES

SITC 775: Household-type electrical. All sub-headings at the 6-digit product level included.

PHARMACEUTICALS*

SITC 541: Medicinal and pharmaceuticals, other than medicaments of group 542. Sub-headings at the 6-digit product level included: SITC 542: Medicaments, including veterinary medicaments. Sub-headings at the 6-digit product level included: SITC 5413: Antibiotics, not put up as medicaments; SITC 5415: Hormones, natural, or reproduced by synthesis, in bulk; SITC 5416: Glycosides, glands, antisera, vaccines and simi- lar products; SITC 5421: medicaments, antibiotics; SITC 5422: Medicaments, hormones, e.t.c.

POWER GENERATING EQUIPMENT

SITC 712: Steam turbines and other vapour turbines and parts thereof, n.e.s.; SITC 716: Rotating electric plant, n.e.s.; SITC 718: Power-generating machinery and parts thereof, n.e.s. All sub-headings at the 6-digit product level included.

(Table B.1 – Continued)

COMPUTER AND OFFICE MACHINES*

SITC 752: Automatic data processing machines and units thereof; magnetic or optical readers; machines transcribing coded media and processing such data. All sub-headings at the 6-digit product level included. SITC 75113: automatic typewriters; word-processing machines; SITC 75131: electrostatic photocopying apparatus operating by reproducing the original image directly onto the copy (direct process); SITC 75132: electrostatic photocopying apparatus operated by reproducing the original image via an intermediate onto the copy (indirect process); SITC 75134: non-electrostatic photocopying apparatus of the contact type; SITC 75997: parts of automatic data processing machines and units thereof, magnetic or optical readers, and machines for transcribing and processing data.

ELECTRONICS AND TELECOMMUNICATIONS*

SITC 764: telecommunications equipment parts n.e.s. All sub-headings at the 6-digit product level included. SITC 7722: printed circuits; SITC 7763: diodes, transistors, etc.; SITC 7764: electronic microcircuits; SITC 7768: electronic computer parts, crystals; SITC 76381: video-recording or reproducing apparatus, whether or not incorporating; SITC 76383: other sound-reproducing apparatus; SITC 77261: boards, panels (including numerical control panels), consoles, desks, cab; SITC 77318: optical fibre cables; SITC 77625: microwave tubes (excluding grid-controlled tubes).

ELECTRICAL MACHINERY

SITC 778: Electrical machinery and apparatus. All sub-headings at the 6-digit product level included.

SCIENTIFIC INSTRUMENTS*

SITC 774: electro-diagnostic apparatus for medical, surgical, dental or veterinary sciences and radiological apparatus. All sub-headings at the 6-digit product level included. SITC 874: measuring, checking, analysis, controlling instruments, n.e.s., parts; SITC 8711: binoculars, monoculars, other optical telescopes, and mountings thereof; Other astronomical instruments and mounting thereof; SITC 8713: non-optical micro- scope, etc.; SITC 8719: liquid crystal devices, n.e.s.; lasers (other than laser diodes); other optical appliances and instruments, n.e.s.; SITC 87211: dental drill engines, whether or not combined on a single base with other dental equipment; SITC 88111: photographic (other than cinematographic) cameras; SITC 88121: cinematographic cameras; SITC 88411: contact lenses; SITC 88419: optical fibres, optical fibre bundles and cables; sheets and plates of polarising material; unmounted optical elements, n.e.s.; SITC 89961: hearing aids (excluding parts and accessories); SITC 89963: Orthopaedic or fracture appliances, including artificial joints; SITC 89967: pacemakers for stimulating heart muscles (excluding parts and accessories).

Notes:
n.e.s: not elsewhere specified.
Sub-sectors are based on this list of SITC-Rev.3 goods grouped into the technological classes by Lall (2000): https://unctadstat.unctad.org/en/Classifications/DimSitcRev3Products_Ldc_Hierarchy.pdf.
*: For these high-tech sectors I have also made reference to Pham et al. (2017). Source: Own elaboration.

Table B.2. Importing countries.

Afghanistan	Congo	Hungary	Mozambique	Singapore
Albania	Costa Rica	Iceland	Myanmar	Slovakia
Algeria	Croatia	India	Namibia	Slovenia
Andorra	Cuba	Indonesia	Nepal	Somalia
Angola	Cyprus	Iran	Netherlands	Spain
Argentina	Czechia	Iraq	Netherlands Antilles	Sri Lanka
Armenia	Côte d'Ivoire	Ireland	New Caledonia	Sudan
Australia	Dem. People's Rep. of Korea	Israel	New Zealand	Suriname
Austria	Dem. Rep. of the Congo	Italy	Nicaragua	Sudan (former)
Azerbaijan	Denmark	Jamaica	Niger	Swaziland
Bahamas	Djibouti	Japan	Nigeria	Sweden
Bahrain	Dominica	Jordan	Norway	Switzerland
Bangladesh	Dominican Rep.	Kazakhstan	Oman	Syria
Barbados	Ecuador	Kenya	Pakistan	Tajikistan
Belarus	Egypt	Kuwait	Panama	Thailand
Belgium and Luxembourg	El Salvador	Kyrgyzstan	Papua New Guinea	Togo
Belize	Equatorial Guinea	Lao People's Dem. Rep.	Paraguay	Trinidad and Tobago
Benin	Eritrea	Latvia	Peru	Tunisia
Bosnia Herzegovina	Estonia	Lebanon	Philippines	Turkey
Botswana	Ethiopia	Lesotho	Plurinational State of Bolivia	Turkmenistan
Brazil	Fiji	Liberia	Poland	USA
Brunei Darussalam	Finland	Libya	Portugal	Uganda
Bulgaria	France	Lithuania	Qatar	Ukraine
Burkina Faso	French Polynesia	Macedonia	Republic of Korea	United Arab Emirates
Burundi	Gabon	Madagascar	Republic of Moldova	United Kingdom
Cabo Verde	Gambia	Malawi	Romania	United Rep. of Tanzania
Cambodia	Georgia	Malaysia	Russian Federation	Uruguay
Cameroon	Germany	Maldives	Rwanda	Uzbekistan
Canada	Ghana	Mali	St. Lucia	Vanuatu
Central African Republic	Greece	Malta	St. Vincent & the Grenadines	Venezuela
Chad	Guatemala	Marshall Islands	Sao Tome & Principe	Viet Nam
Chile	Guinea	Mauritania	Saudi Arabia	Yemen
*China, Hong Kong**	Guinea-Bissau	Mauritius	Senegal	Zambia
*China, Macau**	Guyana	Mexico	Serbia	Zimbabwe
Colombia	Haiti	Mongolia	Seychelles	
Comoros	Honduras	Morocco	Sierra Leone	

Notes: Hong Kong and Macau are excluded from the sample of destination countries in all the specification in which their exports are combined with those of mainland China. See sub-section 5.4 for further details on this.

Table B.3. Chinese export displacement effect analysis on medium-technology sub-sectors: OLS estimates.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$						
Sector	Automotive	Chemicals	Plastics	Iron and steel	Engines and motors	Non-electrical machinery	Household appliances
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS	OLS
$\log(EXP)_{CHN,j,h,t}$	0.058***	0.063***	0.035**	–0.052**	0.073***	0.039***	–0.047***
	(0.007)	(0.009)	(0.015)	(0.020)	(0.007)	(0.005)	(0.007)
$\log(GDP)_{ZAF,t}$	0.184***	0.135**	0.105**	0.213***	0.231**	0.174***	0.324***
	(0.012)	(0.042)	(0.054)	(0.027)	(0.076)	(0.021)	(0.069)
$\log(GDP)_{j,t}$	0.276***	0.211***	0.191***	0.287***	0.412***	0.134***	0.453***
	(0.017)	(0.015)	(0.023)	(0.029)	(0.035)	(0.008)	(0.032)
$\log(dist)_{ZAF,j}$	–1.134***	–1.204***	–1.000***	–0.708**	–1.026***	–1.014***	–1.067***
	(0.114)	(0.065)	(0.099)	(0.141)	(0.135)	(0.034)	(0.143)
$Border_{ZAF,j}$	0.902**	1.064***	0.716***	1.243***	0.965**	0.855***	0.785**
	(0.281)	(0.160)	(0.202)	(0.269)	(0.363)	(0.082)	(0.294)
$Language_{ZAF,j}$	0.356**	0.314***	0.411***	0.090	0.407**	0.361***	0.365***
	(0.108)	(0.051)	(0.076)	(0.114)	(0.123)	(0.027)	(0.104)
$FTA_{ZAF,j,t}$	0.376**	–0.076	0.101	–0.267*	0.194	0.031	0.046
	(0.114)	(0.057)	(0.084)	(0.134)	(0.121)	(0.027)	(0.105)
Observations	25,359	57,855	30,162	18,457	10,149	162,983	12,027
R^2	0.156	0.137	0.129	0.120	0.178	0.132	0.171

Notes: 1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*. 2. All specifications report OLS estimates 3. Standard errors in parentheses, clustered at both product and exporter-importer level. 3. Constant term omitted. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Source: Author's calculations using UN Comtrade 6-digit product-level data.

Table B.4. Chinese export displacement effect analysis on selected sub-sectors of non-electrical machinery: OLS estimates.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$					
Sector	Non-electrical machinery	General purpose machinery	Special purpose machinery	Metalworking machines and machine tools	Mining machinery	Other special purpose machinery
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS
$\log(EXP)_{CHN,j,h,t}$	0.039***	0.087***	0.101***	0.071***	0.092***	0.112***
	(0.005)	(0.006)	(0.008)	(0.014)	(0.009)	(0.009)
$\log(GDP)_{ZAF,t}$	0.174***	0.164***	0.185***	0.335***	0.265**	0.191***
	(0.021)	(0.026)	(0.039)	(0.066)	(0.093)	(0.043)
$\log(GDP)_{j,t}$	0.134***	0.173***	0.167***	0.189***	0.204***	0.187***
	(0.008)	(0.010)	(0.012)	(0.020)	(0.045)	(0.016)
$\log(dist)_{ZAF,j}$	–1.014***	–1.991***	–0.840***	–0.811***	–0.988***	–0.791***
	(0.034)	(0.043)	(0.064)	(0.083)	(0.134)	(0.072)
$Border_{ZAF,j}$	0.855***	1.021***	0.832***	0.825***	1.019***	0.773***
	(0.082)	(0.105)	(0.145)	(0.146)	(0.289)	(0.159)
$Language_{ZAF,j}$	0.361***	0.489***	0.209***	0.0241	0.420***	0.178*
	(0.027)	(0.035)	(0.049)	(0.051)	(0.103)	(0.054)
$FTA_{ZAF,j,t}$	0.031	0.093	–0.028**	–0.064	0.302**	–0.086
	(0.027)	(0.036)	(0.048)	(0.058)	(0.106)	(0.053)
Observations	162,983	99,420	47,472	16,091	9,091	38,381
R^2	0.132	0.167	0.120	0.118	0.203	0.171

Notes: 1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*. 2. All specifications report OLS estimates 3. Standard errors in parentheses, clustered at both product and exporter-importer level. 3. Constant term omitted. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Source: Author's calculations using UN Comtrade 6-digit product-level data.

Table B.5. Chinese export displacement effect analysis on high-technology sub-sectors: OLS estimates.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$					
Sector	Pharmaceuticals	Power generating equipment	Computer and office machines	Electronics and telecommunications	Electrical machinery	Scientific instruments
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS
$\log(EXP)_{CHN,j,h,t}$	0.098***	0.075***	0.092***	0.062***	0.043***	0.054***
	(0.008)	(0.009)	(0.007)	(0.004)	(0.004)	(0.007)
$\log(GDP)_{ZAF,t}$	0.142**	0.203***	0.277***	0.129**	0.204***	0.196***
	(0.024)	(0.039)	(0.066)	(0.063)	(0.027)	(0.014)
$\log(GDP)_{j,t}$	0.253***	0.130***	0.207***	0.220***	0.217***	0.175***
	(0.025)	(0.014)	(0.022)	(0.020)	(0.020)	(0.054)
$\log(dist)_{ZAF,j}$	–0.927***	–1.448***	–1.763***	–1.527***	–1.257***	–1.096***
	(0.109)	(0.059)	(0.104)	(0.097)	(0.086)	(0.055)
$Border_{ZAF,j}$	0.552**	0.998***	0.713**	0.288*	1.150***	0.602***
	(0.317)	(0.156)	(0.322)	(0.125)	(0.209)	(0.143)
$Language_{ZAF,j}$	0.326**	0.607***	0.796***	0.371***	0.553***	0.386***
	(0.096)	(0.048)	(0.082)	(0.073)	(0.072)	(0.044)
$FTA_{ZAF,j,t}$	–0.344**	0.178	0.152	–0.073	0.076	0.046
	(0.105)	(0.044)	(0.074)	(0.070)	(0.068)	(0.040)
Observations	13,188	47,125	17,264	23,494	23,250	47,633
R^2	0.122	0.220	0.262	0.170	0.190	0.132

Notes: 1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*. 2. All specifications report OLS estimates 3. Standard errors in parentheses, clustered at both product and exporter-importer level. 3. Constant term omitted. * $p < 0.10$, ** $p < 0.05$, $^{***}p < 0.01$. Source: Author's calculations using UN Comtrade 6-digit product-level data.

Table B.6. Chinese export displacement effect analysis in different groups of destination countries: OLS estimates.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$				
Destination	OECD	Non-OECD	Main partners§	Africa	Sub-Saharan Africa
Estimation method	OLS	OLS	OLS	OLS	OLS
$\log(EXP)_{CHN,j,h,t}$	0.068***	0.081***	0.076***	0.028***	0.033***
	(0.006)	(0.004)	(0.008)	(0.003)	(0.005)
$\log(GDP)_{ZAF,t}$	0.264***	0.371***	0.399***	0.334***	0.378***
	(0.011)	(0.016)	(0.058)	(0.020)	(0.020)
$\log(GDP)_{j,t}$	0.312***	0.363***	0.511***	0.362***	0.413***
	(0.013)	(0.006)	(0.087)	(0.017)	(0.016)
$\log(dist)_{ZAF,j}$	–0.407***	–0.848***	–1.742***	–0.916***	–0.902***
	(0.097)	(0.024)	(0.350)	(0.038)	(0.042)
$Border_{ZAF,j}$	-	0.857***	-	0.626***	0.593***
		(0.019)		(0.059)	(0.061)
$Language_{ZAF,j}$	0.315***	0.308***	0.358***	0.416***	0.404***
	(0.045)	(0.021)	(0.084)	(0.025)	(0.026)
$FTA_{ZAF,j,t}$	–0.180***	0.307***	–0.081*	0.250***	0.218***
	(0.029)	(0.029)	(0.050)	(0.034)	(0.035)
Observations	167,173	325,650	45,086	185,676	172,102
R^2	0.101	0.163	0.097	0.234	0.248

Notes: 1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*. 2. All specifications report OLS estimates 3. Standard errors in parentheses, clustered at both product and exporter-importer level. 3. Constant term omitted. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Source: Author's calculations using UN Comtrade 6-digit product-level data.

Table B.7. Chinese export displacement effect analysis on the restricted sample (i.e., exports > US$10,000).

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$	
Specification	(1)	(2)
Estimation method	OLS	TSLS/GMM
$\log(EXP)_{CHN,j,h,t}$	0.057***	–0.140***
	(0.003)	(0.006)
$\log(GDP)_{ZAF,t}$	0.138***	0.312***
	(0.013)	(0.013)
$\log(GDP)_{j,t}$	0.136***	0.294***
	(0.006)	(0.008)
$\log(dist)_{ZAF,j}$	–0.663***	–0.550***
	(0.023)	(0.025)
$Border_{ZAF,j}$	0.606***	0.637***
	(0.049)	(0.055)
$Language_{ZAF,j}$	0.206***	0.201***
	(0.018)	(0.019)
$FTA_{ZAF,j,t}$	0.081***	0.025
	(0.019)	(0.019)
Constant	1.032***	1.923***
	(0.403)	(0.413)
Observations	324,325	324,325
R-squared	0.152	-
First-stage *F*-stat.	-	4133.82
[*p*-value]		[0.000]
Endogeneity test.	-	1113.01
[*p*-value]		[0.000]
Pagan-Hall	-	2179.53
[*p*-value]		[0.000]
Hansen *J*-stat.	-	0.219
[*p*-value]		[0.528]

Notes:

1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*.
2. Log GDP of China and log distance from China to country *j* are used as IV in (2).
3. Standard errors in parentheses are clustered at both product and exporter-importer level.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Author's calculations using UN Comtrade 6-digit product-level data.

Table B.8. Chinese export displacement effect analysis exports from Hong Kong and China combined.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$	
Specification	(1)	(2)
Estimation method	OLS	TSLS/GMM
$\log(EXP)_{CHN,j,h,t}$	0.052***	–0.185***
	(0.003)	(0.007)
$\log(GDP)_{ZAF,t}$	0.137***	0.354***
	(0.013)	(0.013)
$\log(GDP)_{j,t}$	0.184***	0.406***
	(0.005)	(0.008)
$\log(dist)_{ZAF,j}$	–1.126***	–0.974***
	(0.022)	(0.024)
$Border_{ZAF,j}$	0.862***	0.952***
	(0.052)	(0.061)
$Language_{ZAF,j}$	0.399***	0.364***
	(0.018)	(0.019)
$FTA_{ZAF,j,t}$	0.031*	–0.062**
	(0.018)	(0.019)
Constant	1.212***	1.401**
	(0.40)	(0.423)
Observations	492,823	324,325
R-squared	0.127	-
First-stage *F*-stat. [*p*-value]	-	4133.82 [0.000]
Endogeneity test. [*p*-value]	-	1113.01 [0.000]
Pagan-Hall [*p*-value]	-	2179.53 [0.000]
Hansen *J*-stat. [*p*-value]	-	0.219 [0.528]

Notes:

1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*.
2. Log GDP of China and distance from China to country *j* are used as IV in (2).
3. Standard errors in parentheses are clustered at both product and exporter-importer level.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: Author's calculations using UN Comtrade 6-digit product-level data.

Table B.9. Chinese export displacement effect analysis on medium-technology sub-sectors: before and after GFC.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$					
Sector	Sub-period	$\log(EXP)_{CHN}$	Obs.	First-stage *F*-stat. [*p*-value]	Endogeneity test. [*p*-value]	Hansen *J*-stat. [*p*-value]
Automotive	1995-2006	–0.008 (0.059)	9,370	203.23 [0.000]	27.10 [0.000]	1.427 [0.234]
	2010-2018	–0.071** (0.024)	13,224	196.89 [0.000]	13.36 [0.000]	1.515 [0.219]
Chemicals	1995-2006	–0.250** (0.073)	19,212	102.06 [0.000]	41.00 [0.000]	0.488 [0.485]
	2010-2018	–0.043* (0.081)	29,555	75.84 [0.000]	27.19 [0.000]	0.145 [0.704]
Plastics	1995-2006	–0.147** (0.043)	9,736	301.94 [0.000]	19.76 [0.000]	1.632 [0.205]
	2010-2018	–0.016 (0.082)	15,720	99.81 [0.000]	15.42 [0.000]	1.786 [0.181]
Iron and steel	1995-2006	–0.117** (0.022)	6,697	97.71 [0.000]	13.62 [0.000]	1.573 [0.221]
	2010-2018	–0.821*** (0.051)	8,782	102.06 [0.000]	12.47 [0.000]	1.685 [0.198]
Engines and motors	1995-2006	–0.192** (0.073)	3,084	52.13 [0.000]	26.08 [0.000]	1.803 [0.179]
	2010-2018	–0.252*** (0.034)	5,479	45.65 [0.000]	16.36 [0.000]	1.941 [0.164]
Non-electrical machinery	1995-2006	–0.133*** (0.010)	130,946	1740.88 [0.000]	1084.03 [0.000]	1.375 [0.241]
	2010-2018	–0.197*** (0.009)	139,911	2012.31 [0.000]	561.75 [0.000]	1.456 [0.217]
Household appliances	1995-2006	–0.183*** (0.073)	4,467	96.88 [0.000]	17.77 [0.000]	2.248 [0.134]
	2010-2018	–0.503*** (0.132)	5,737	85.16 [0.000]	19.78 [0.000]	2.482 [0.121]

Notes:
1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*.
2. Log GDP of China and log distance from China to country *j* are used as IV.
3. Standard errors in parentheses are clustered at both product and exporter-importer level.
4. Constant and other regressors term omitted.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Source: Author's calculations using UN Comtrade 6-digit product-level data.

Table B.10. Chinese export displacement effect analysis on non-electrical machinery sub-sectors: before and after GFC.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$					
Sector	Sub-period	$\log(EXP)_{CHN}$	Obs.	First-stage F-stat. [p-value]	Endogeneity test. [p-value]	Hansen J-stat. [p-value]
General purpose machinery	1995-2006	–0.102*** (0.023)	31,908	864.60 [0.000]	169.47 [0.000]	0.166 [0.683]
	2010-2018	–0.308*** (0.050)	51,967	263.23 [0.000]	148.85 [0.000]	0.174 [0.676]
Special purpose machinery	1995-2006	–0.090** (0.033)	15,435	348.68 [0.000]	50.04 [0.000]	2.091 [0.111]
	2010-2018	–0.148*** (0.009)	24,400	115.03 [0.000]	57.04 [0.000]	0.040 [0.841]
Metalworking machines and machine tools	1995-2006	–0.043 (0.073)	5,370	98.79 [0.000]	17.03 [0.000]	1.802 [0.162]
	2010-2018	–0.316*** (0.021)	8,150	63.54 [0.000]	11.38 [0.000]	2.451 [0.117]
Mining machinery	1995-2006	–0.026 (0.033)	2,623	92.45 [0.000]	39.16 [0.000]	1.502 [0.135]
	2010-2018	–0.312** (0.123)	4,912	67.12 [0.000]	29.05 [0.000]	1.602 [0.172]
Other special purpose machinery	1995-2006	–0.044* (0.022)	12,812	286.61 [0.000]	23.07 [0.000]	0.483 [0.419]
	2010-2018	–0.072*** (0.014)	19,488	97.35 [0.000]	24.78 [0.000]	0.342 [0.558]

Notes: 1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*. 2. Log GDP of China and log distance from China to country *j* are used as IV. 3. Standard errors in parentheses are clustered at both product and exporter-importer level. 4. Constant and other regressors term omitted. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Source: Author's calculations using UN Comtrade 6-digit product-level data.

Table B.11. Chinese export displacement effect analysis on high-technology sub-sectors: before and after GFC.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$					
Sector	Sub-period	$\log(EXP)_{CHN}$	Obs.	First-stage F-stat. [p-value]	Endogeneity test. [p-value]	Hansen J-stat. [p-value]
Pharmaceuticals	1995-2006	–0.061 (0.201)	4,887	56.23 [0.000]	17.11 [0.000]	1.229 [0.267]
	2010-2018	–0.128* (0.034)	6,963	30.64 [0.000]	9.49 [0.002]	0.061 [0.804]
Power generating equipment	1995-2006	–0.050 (0.034)	15,960	209.28 [0.000]	32.88 [0.000]	1.403 [0.235]
	2010-2018	–0.324*** (0.065)	23,714	105.18 [0.000]	27.19 [0.000]	1.557 [0.212]
Computer and office machines	1995-2006	–0.164** (0.057)	6,967	82.27 [0.000]	38.77 [0.000]	2.132 [0.118]
	2010-2018	–0.041 (0.081)	7,898	20.54 [0.000]	29.45 [0.000]	2.086 [0.102]
Electronics and telecommunications	1995-2006	–0.014 (0.040)	8,669	199.60 [0.000]	19.69 [0.000]	1.586 [0.209]
	2010-2018	–0.151*** (0.026)	10,924	143.23 [0.000]	16.76 [0.000]	0.329 [0.566]
Electrical machinery	1995-2006	–0.060 (0.056)	8,057	102.53 [0.000]	10.83 [0.000]	2.003 [0.129]
	2010-2018	–0.214*** (0.030)	11,651	78.26 [0.000]	9.01 [0.000]	2.198 [0.138]
Scientific instruments	1995-2006	–0.165*** (0.037)	15,442	254.68 [0.000]	52.56 [0.000]	0.275 [0.621]
	2010-2018	–0.127** (0.054)	25,006	113.27 [0.000]	51.67 [0.000]	0.028 [0.866]

Notes: 1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*. 2. Log GDP of China and log distance from China to country *j* are used as IV. 3. Standard errors in parentheses are clustered at both product and exporter-importer level. 4. Constant and other regressors term omitted. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Source: Author's calculations using UN Comtrade 6-digit product-level data.

Table B.12. Chinese export displacement effect analysis in different groups of destination countries: before and after the GFC.

Dep. variable	$\log(EXP)_{ZAF,j,h,t}$					
Sector	Sub-period	$\log(EXP)_{CHN}$	Obs.	First-stage F-stat. [p-value]	Endogeneity test. [p-value]	Hansen J-stat. [p-value]
OECD	1995-2006	–0.218*** (0.025)	69,067	641.41 [0.000]	179.98 [0.000]	0.821 [0.315]
	2010-2018	–0.264*** (0.053)	73,271	72.86 [0.000]	22.116 [0.002]	0.451 [0.502]
Africa	1995-2006	0.307** (0.120)	47,691	54.85 [0.000]	63.45 [0.000]	0.579 [0.412]
	2010-2018	–0.956*** (0.133)	107,771	77.12 [0.000]	395.86 [0.000]	2.929 [0.116]
Sub-Saharan Africa	1995-2006	0.273** (0.132)	43,336	32.04 [0.000]	54.81 [0.000]	0.771 [0.380]
	2010-2018	–0.954*** (0.156)	100,993	53.41 [0.000]	281.47 [0.000]	2.198 [0.127]

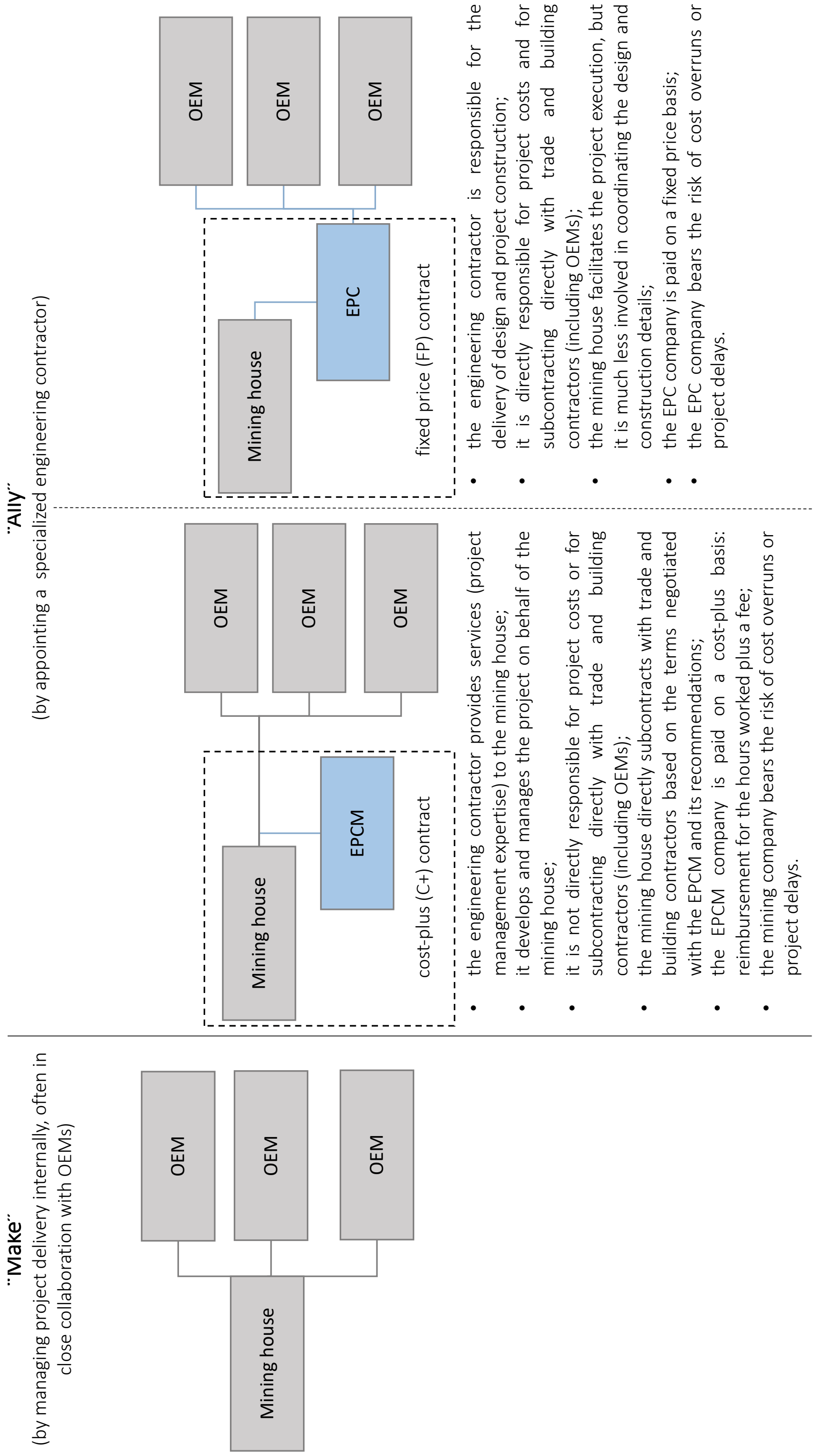
Notes: 1. Dependent variable is log exports of South Africa in product *h*, to country *j*, in year *t*. 2. Log GDP of China and log distance from China to country *j* are used as IV. 3. Standard errors in parentheses are clustered at both product and exporter-importer level. 4. Constant and other regressors term omitted. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Source: Author's calculations using UN Comtrade 6-digit product-level data.

Appendix C – Appendix to Chapter 5

Section C.1

C.1.1. ‘Make’ or ‘ally’ contracting models in mining value chains

Figure C.1.1. Contracting models for the exploration-development (or expansion) phases of a mining project.



Source: Own elaboration based on relevant secondary literature and engagement with industry representatives.

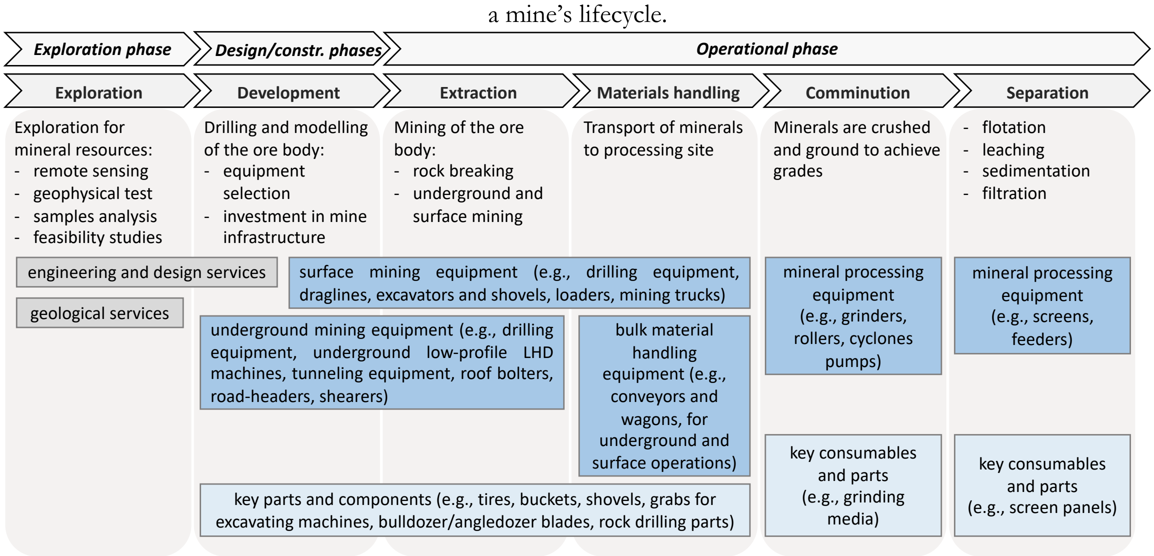
C.1.2. Main product segments in mining equipment

The mining machinery industry includes a wide spectrum of equipment used along the different stages of a mine's lifecycle (i.e., from exploration to refining). For the purpose of the present work, the mining equipment industry has been segmented into four main product categories:

1. Underground mining equipment (e.g., drilling equipment, underground low-profile load-haul-dump machines, tunnelling equipment, hydraulic roof supports, roof bolters, road-headers, shearers);
2. Surface mining equipment (e.g., drilling equipment, draglines, excavators and shovels, loaders, mining trucks);
3. Mineral processing equipment (e.g., crushers, cyclones, feeders, screens, grinders);[183]
4. Bulk material handling equipment (e.g., conveyors, wagons).

Each of these categories includes a vast range of inputs used in the various stages of a mine's life, from relatively less to relatively more complex, customised, innovation-intensive equipment and parts. Figure C.1.2 plots this product segmentation against the key stages of a mine's development.

Figure C.1.2. Mining equipment and machines operated on site along the different stages of a mine's lifecycle.



Source: Own elaboration based on secondary literature and engagement with industry representatives.

Unfortunately, publicly available trade and production classifications do not allow specific data on those product segments to be obtained, for at least two reasons. First of all, underground

[183] This category only includes equipment used for on-site material comminution, separation and refining. Other mineral processing and beneficiation equipment mainly operated off site is not included here.

and surface equipment are not disaggregated in the official trade and production databases.[184] Second, much of the earthmoving equipment used for surface mining might also be employed in the construction industry. Given these limitations, as far as secondary trade data is concerned, the research has identified four main segments/categories: *i*) surface and underground mining equipment; *ii*) mineral processing equipment; *iii*) materials handling components and equipment; and *iv*) wear parts, as per Bamber et al. (2016). Engagements with key stakeholders, industry players and associations have assisted in developing the list of products.[185] Data is restricted to the 6-digit level due to the unavailability of 8-digit level HS code data for every country and product in the list. Some efforts have been made to exclude products at 6-digit mainly used in construction, but mining equipment trade figures might still be overestimated. This list is obviously not exhaustive, particularly as far as wear parts and components are concerned. However, it focuses on categories of products that have been identified as particularly important through literature and engagements with industry experts and representatives. Table C.1.1 reports the detailed list of products at 6-digit level.[186]

Table C.1.1. Segmentation of Mining Machinery and Equipment Products.

HS code	Description
1st	**Surface and underground**
820713	Rock drilling or earth boring tools: with working part of cements
842911	Bulldozers and angledozers: track laying
842919	Bulldozers and angledozers: other
842920	Graders and levellers
842930	Scrapers
842940	Tamping machines and road rollers
842951	Mechanical shovels, excavators, shovel loaders: front end shovel loaders
842952	Mechanical shovels, excavators, shovel loaders: with a 360° revolving superstructure
842959	Mechanical shovels, excavators, shovel loaders: other
843010	Pile-drivers and pile-extractors
843031	Coal or rock cutters and tunnelling machinery: self-propelled
843039	Coal or rock cutters and tunnelling machinery: other
843041	Other boring or sinking machinery: self-propelled
843049	Other boring or sinking machinery: other
843050	Other machinery, self-propelled

[184] While often used for similar applications, underground equipment is generally smaller in size (i.e., low-profile machines) and far more resistant than surface equipment.

[185] To finalise this product list, I have consulted with the SACEEC, the MEMSA, the MCSA and a number of experts within the sector.

[186] These categories broadly coincide with those listed in the United States International Trade Administration definition. According to their classification, this equipment includes coal breakers, cutters and pulverisers; underground mining core drills; minerals processing machinery; mining cars; stationary rock crushing machinery; excavating machinery; and conveyor systems. See also Bamber et al. (2016) on this.

(*Table C.1.1 – Continued)*

843061	Other machinery, not self-propelled: tamping or compacting machinery
843062	Other machinery, not self-propelled: scrapers
843069	Other machinery, not self-propelled: other
845910	Way-type unit head machines
845940	Other boring machines
845970	Other threading or tapping machines
870130	Track-laying tractors
870410	Motor vehicles for the transport of goods: dumpers designed for off-highway use:
870422	Diesel powered trucks – G.V.M. exceeding 5t but not exceeding 20 t
870423	Diesel powered trucks – G.V.M. exceeding 20 t
2nd	**Mineral processing**
841370	Centrifugal pumps n.e.s.
841381	Pumps n.e.s.
845510	Tube mills
841710	Industrial or laboratory furnaces and ovens, of ores, pyrites or of metals of ores,
845521/22	Other rolling mills: hot, combination hot and cold, cold
847410	Sorting, screening, separating or washing machines
847420	Crushing or grinding machines
847439	Mixing or kneading machines: other
847480	Machines to agglomerate, shape, mould minerals or fuel
847982	Other machine for mixing, kneading, crushing, grinding screening
3rd	**Material handling**
401011	Conveyor belt metal reinforced vulcanised rubber
401012	Conveyor belt textile reinforced vulcanised rubber
401019	Conveyor belts of vulcanised rubber nes
591000	Transmission or conveyor belts or belting of textile material
842320	Scales for continuous weighing of goods on conveyors
842520	Pit-head winding gear, winches specially designed for use underground
842542	Other jacks and hoists, hydraulic
842611	Overhead travelling cranes on fixed support
842612	Mobile lifting frames on tyres and straddle carriers
842620	Tower cranes
842630	Portal or pedestal jib cranes
842710/20	Self-propelled trucks powered by an electric motor and other self-propelled trucks
842790	Other trucks
842831	Mine conveyors/elevators
842833	Continuous action elevators/conveyors for goods/mat, belt type n.e.s.
842850	Mine wagon pushers, locomotive or wagon traversers, wagon tippers and similar
842890	Other lifting handling or loading machinery
4th	**Wear parts and components**
401180	Pneumatic tyres, of rubber of a kind used on construction, mining or industrial
732591	Balls, iron or steel, cast, for grinding mills
820712	Parts of rock drilling or earth boring tools except carbide
841391	Parts of pumps for liquid whether or not fitted with a measuring device
841790	Parts for furnaces and ovens for the roasting, melting or other heat-treatment of ores,
843110	Parts of hoists and winches
843120	Parts for machines of headings 8425 – 8430
843131	Parts of lifts, skip hoist or escalators

(*Table C.1.1 – Continued)*

843139	Parts of lifting/handling machinery n.e.s.
843141	Buckets, shovels, grabs etc. etc., for excavating machinery
843142	Bulldozer and angledozer blades
843143	Parts of boring or sinking machinery
843149	Parts of cranes, work-trucks, shovels
845530	Rolls for rolling mills
847490	Parts of machinery for working mineral substances
848180/90	Taps, cocks, valves and similar appliances, n.e.s. and parts
730840	Equipment for scaffolding, shuttering, propping or pit-propping

Notes:
n.e.s: not elsewhere specified.
Source: Own elaboration based on relevant secondary literature and engagement with industry representative.

Section C.2

C.2.1. Interview models for selected key firm actors

A. Interview model for OEMs[187]

A1. Introduction and overview of the business model and its evolution

1. Introduction and validation of the graphical tools
2. For the following dimensions ask about current and past (ten and/or five years):
    a. positioning in functional stages of the value chain (*here show graphical tools*);
    b. establishment date (in South Africa) and, for foreign companies, reason to invest in South Africa;
    c. ownership;
    d. size (number of employees in South Africa and/or turnover of South African plants/subsidiaries);
    e. main products;
    f. main activities/functional specialisation (*here show graphical tools and ask if the value chain functions are well represented or something missing*);
    g. main markets (and share of these markets and for how long they have been there).
3. What are the main reasons for such changes?
4. Could you please rank the value chain stages (and specific activities/functions) in terms of value added in the sector?
5. Which are the areas of the value chain where is it possible to capture higher value added?
6. What is the main value proposition of your company in your engagement of potential clients? Reliability? Quality? International outlook? Domestic knowledge? MRO? Etc.

A2. Main customers and the restructuring dynamics on the demand side

1. Who are your main clients (companies' names, if possible)? Are they mainly 'traditional investors' (US, UK, Canadian, Australian, South African) or do you also supply to 'emerging investors' (China, India)? Where are they (South Africa, other sub-Saharan African countries, others)?
2. Do you supply them directly or through local distributors and/or project

[187] This interview model is mainly intended for South African OEMs. Starting from this template the interview models for TFSs and Chinese OEMs have been developed, focusing on the specific issues pertaining to these firm actors.

houses/mining consulting companies?

3. What kind of interactions do you have with your clients? What are the most important criteria that drive your clients' selection of suppliers? What do you supply in terms of products/services that other competitors are not able to supply?
4. Do you have a standard portfolio of products/services for all your clients? To what extent you are involved in customisation? In offering these customised products/services to your buyers, to what extent do they influence/have a preference/have a say on your suppliers' selection?
5. Have these buyer relationships changed over the past ten and/or five years and why?
6. Would you say that traditional and emerging mining houses have different:
    a. outsourcing strategies (they are more vertically integrated or not?);
    b. supplier selection processes? (tender? formal audits?).
7. How do such different strategies have an influence on:
    a. your position on the value chain, business strategies;
    b. your competitiveness/performance/growth prospects;
    c. your suppliers' competitiveness/performance/growth prospects.

A3. Main suppliers and the restructuring dynamics on the supply side

1. Where do you source (e.g., internally, locally, imported and companies' names if possible):
    a. research and product development services (design, rapid prototyping);
    b. sub-assembled manufacturing (general purpose machinery, valves);
    c. components (metal castings, metal work, electrical components);
    d. raw materials (basic metals, plastics, ceramics, rubber etc.);
    e. capital equipment.
2. Who would you say are your most critical suppliers (companies' names, if possible) and why?
3. What are the main criteria that drive your supplier selection process along the different stages of the value chain?
4. Are there cases/projects in which your suppliers are selected by other players like project houses or mining companies? If yes, what criteria do they use and what impact does it have on your business and supply chain?
5. When importing, why? Costs/quality/local availability/other reasons?
    a. research and product development services (design, rapid prototyping);

    b. sub-assembled manufacturing (general purpose machinery, valves);
    c. components (metal castings, metal work, electrical components);
    d. raw materials (basic metals, plastics, ceramics, rubber etc);
    e. capital equipment.
6. What are the top five countries from which you are importing?
7. Did this supply structure change over the past ten and/or five years and why? (e.g., more import in certain segments, more vertical integration, more/less local sourcing, consolidation in the list of suppliers, etc.)
8. How has the engagement with your suppliers changed over time and have you established partnerships for upgrading your supply chain? (for example, have you established JVs, shares acquisitions, outsource functions or re-internalising functions, vertically integrated stages of the value chains, functional upgrade, lateral migration)?
9. How these changes have affected:
    a. your competitiveness/performance/growth prospects;
    b. your clients' competitiveness/performance/growth prospects;
    c. your suppliers' competitiveness/performance/growth prospects (local, import supplier).

A4. The competitive environment and its evolution

1. What are the main competitive challenges you and/or the mining equipment cluster have faced during the last decades? How would you rank them in importance/impact on your business (from the highest to the lowest)?

Bottleneck	Rank
Raw material/component costs	
Raw material/component quality	
Raw material/component availability	
Electricity cost	
Access to (and cost of) capital	
Declining mining production and investments	
High concentration and ownership control	
Lack of STEM/artisanal/technical skills	
…………………………………………………………………………	
………………………………………………………………………….	

2. Would you say that they have been responsible for driving or at least interacting with import competition from China?

3. Are there cases of unfair competition (dumping, custom coding, etc.)?
4. What are the instruments/strategies your competitors are using to penetrate the South African and regional markets in which you operate? Are these mainly related to product cost, product quality/functionalities, services (including financial services – e.g., leasing) or a combination of them (i.e., package)?
5. Are there any policies that the government have recently adopted that you think are positively tackling any of these challenges?
6. What are the challenges in implementing the localisation policy for your company?

A5. Other parameters of interests

1. Top three products by domestic market share? Have they changed over the last three years?
2. Share of domestic sales vis-à-vis export share? Which are your top three export markets?
3. What are the three main raw materials/components you are importing and what are their prices with respect to locally produced ones?
4. What proportion of your turnover comes from production?
5. What proportion of your turnover comes from post-sales services (including MRO)?
6. What has been the profits trend over the past five to seven years?
7. Have you invested in capital equipment in the last five or three years? Do you have a strategic plan of investments for the forthcoming years?
8. Have you introduced any new products in the last five and/or seven years? What has driven this introduction? Do you have any new product in the pipeline?
9. As a share of your turnover, how much have you spent on new capital equipment investments, R&D, royalties and licenses, and training in the last five and/or seven years?

B. Interview model for mining houses

B1. Introduction and overview of the business model and its evolution

1. Introduction and validation of the graphical tools.
2. For the following dimensions, ask about current and past (ten and/or five years):
    a. positioning in functional stages of the value chain (*show graphical tool);*
    b. establishment date (in South Africa) and, for foreign companies, reason to invest in South Africa and/or in other sub-Saharan countries;

c. ownership;

d. size (number of employees in South Africa and/or turnover of South African and sub-Saharan mining operations);

e. main commodities mined and main type of mines (open-pit or underground);

f. main activities/functional specialisation (*here show graphical tools and ask if the value chain functions are well represented or something missing*) – i.e., do you own and/or operate the mine?

g. main exporting markets for commodities (and share of these markets and for how long they have been there).

3. What are the main reasons for such changes?
4. Could you please rank the value chain stages (and specific activities/functions) in terms of value added in the sector?
5. Which are the areas of the value chain where is it possible to capture higher value added?

B2. Main end markets and the restructuring dynamics on the demand side:

1. What are the main end-markets for the commodities extracted and/or processed?
2. Have these markets changed over the past 20 years and why? How has the rise of China affected the geography of your end-markets and the price of the commodities that you extract and/or process?
3. How have such changes in the end-markets affected:
   a. your position in the value chain, business strategies;
   b. your competitiveness/performance/growth prospects;
   c. your suppliers' competitiveness/performance/growth prospects (these are the mining equipment manufacturers and project houses the miners select/work with).

B3. Main suppliers and the restructuring dynamics on the supply side:

1. Who would you say are the most critical project houses and mining equipment manufacturers you work with (companies' names if possible) and why?
2. What are the main criteria that drive your equipment manufacturer selection process?
3. Are the financing packages offered by OEMs an important factor on which you base supplier selection? Do you have some kind of role with respect to such financing solutions offered by OEMs (e.g., shared-ownership models)?

4. Which functions have you outsourced in the past 20 years and why? Which ones have you retained and why?
5. How do you select (tender, global partnership with limited integrated solution providers?) and monitor (formal audits?) your suppliers?
6. Are there cases/projects in which you have a say on the suppliers of the OEMs you have selected? If yes, what criteria do you use (e.g., standardisation, input price)? If not, do you have a way to monitor the OEM's suppliers?
7. Do you find it difficult to comply with local content requirements? If yes, why?
8. Has this supply structure changed over the past 20 and/or ten years and why?
9. How has the engagement with your suppliers changed over time and have you established partnerships with them? (for example, have you established JVs, shares acquisitions, outsource functions or re-internalising functions, vertically integrated stages of the value chains, functional upgrade)?
10. How have these changes affected:
    a. your competitiveness/performance/growth prospects;
    b. your suppliers' competitiveness/performance/growth prospects.

C. Interview model for project houses

C1. Introduction and overview of the business model and its evolution

1. Introduction and validation of the graphical tools.
2. For the following dimensions, ask about current and past (ten and/or five years):
    a. positioning in functional stages of the value chain (*show graphical tool)*;
    b. establishment date (in South Africa) and, for foreign companies, reason to invest in South Africa;
    c. ownership;
    d. size (number of employees in South Africa and/or turnover of South African plants/subsidiaries);
    e. main products;
    f. main activities/functional specialisation (*here show graphical tools and ask if the value chain functions are well represented or something missing*);
    g. main markets (and share of these markets and for how long they have been there).
3. What are the main reasons for such changes?
4. Could you please rank the value chain stages (and specific activities/functions) in terms

of value added in the sector?

5. Which are the areas of the value chain where is it possible to capture higher value added?
6. What is the main value proposition of your company in your engagement of potential clients? Reliability? Quality? International outlook? Domestic knowledge? MRO? Etc.

C2. Different contracting models

1. Which are the main differences between EPCMs and EPCs types of contracting in terms of procurement responsibilities (e.g., who has the final say about type and brand of mining equipment to be procured)?
2. How much power in terms of procurement is in the hands of your company under different types of contracting models?
3. Do you act 'simply' as a decision influencer with respect to the equipment to be installed or do you select, specify and co-design the equipment/mining solution together with OEMs?
4. Currently, do you work mainly through EPCM- or EPC-type contracts? What are the factors driving this choice? For example, does the choice of the model depend on: the type of client (e.g., majors vs. large but mainly local mining houses vs. medium-small junior miners?), their internal capabilities and the associated risk profile of the mining project? The type of mine (e.g., underground or open-pit mining); the market (e.g., South Africa vs. other Sub-Saharan countries?)
5. Would you say there has been a sort of evolution over time in the prevalence of a specific type of contracting between mining houses and project houses?
6. In the mining industry the MRO activities are a critical segment of the value chain and one in which there is significant value opportunity. What models are used in the South African context? Is it always the case that the company providing the machinery is the exclusive provider of MRO services or are there mixed models? What are the potential advantages of locally based companies providing MRO services?

C3. Main customers and the restructuring dynamics on the demand side:

1. Who are your main clients?
    a. Are they mainly 'traditional investors' (US, UK, Canadian, Australian, South African) or do you also work with 'emerging investors' (China, India)? Where are they investing (South African, other sub-Saharan countries, others)?

b. Are they mainly ‘major mining companies or ‘small-medium’ size mines – so-called ‘junior’ mines?

2. Have these buyers’ relationships changed over the past ten and/or five years and why?
3. Would you say that traditional and emerging mining houses have different:
    a. outsourcing strategies (they are more vertically integrated or not?);
    b. supplier selection processes? (tender? formal audits?).
4. How do such different strategies have an influence on:
    d. your position in the value chain, business strategies;
    e. your competitiveness/performance/growth prospects;
    f. your suppliers’ competitiveness/performance/growth prospects (these are the mining equipment manufacturers project houses select/work with).
5. What are the main factors affecting buyers’ decisions? For example: cost, quality, reliability, presence of local MRO supplier, financial package for products, others. And are these different for specific segments or types of mine?

C4. Main suppliers and the restructuring dynamics on the supply side:

1. Who would you say are the most critical mining equipment manufacturers you work with (companies’ names if possible) and why?
2. What are the main criteria that drive your equipment manufacturer selection processes?
3. Are there cases/projects in which you or your client have a say on the suppliers of the OEMs you have selected? If yes, what criteria do you (or your client) use (e.g., standardisation, input price?). If not, do you have a way to monitor OEM’s suppliers?
4. Do you have to comply with local content requirements as a project house?
5. Did this supply structure change over the past 10 and/or 5 years and why?
6. How has the engagement with your suppliers changed over time and have you established partnerships with them? (for example, have you established JVs, shares acquisitions, outsource functions or re-internalising functions, vertically integrated stages of the value chains, functional upgrade, lateral migration in other sectors)?
7. How these changes have affected:
    a. your competitiveness/performance/growth prospects;
    b. your clients’ competitiveness/performance/growth prospects;
    c. your suppliers’ competitiveness/performance/growth prospects.

C5. The competitive environment and its evolution

1. According to info from previous interviews, it seems that a limited number of international OEMs have the capabilities to execute large projects and are increasingly operating as your competitors in the global mining sector and in South Africa? Can you please elaborate on that?
2. How is your company responding to this challenge?
3. What about Chinese project houses around Africa? Are they starting to win contracts even with 'traditional' investors (there is some evidence of that in the infrastructure sector, for example)?
4. Are the financing packages offered by OEMs an important factor on which you and your clients base supplier selection? Do you have some kind of role with respect to such financing solutions offered by OEMs?

C.2.2. The DTI's introduction letter.

Figure C.2.2.1. The DTI's introduction letter.

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To whom it may concern

The South African mining equipment value chain: localisation, import competition and policy

Professor Andreoni and Miss Torreggiani are conducting a research project on the relationship between technological and organisational change in the context of high value manufacturing industries in South Africa.

Specifically, they are focusing on how import penetration dynamics have shaped the structure of the supply chain, and the technological trajectories of the mining equipment companies in the Gauteng province, including their internal organisational restructuring and engagement with the domestic supply chain. This analysis will aim at informing the ongoing policies in support of the local supply chain developement and business strategies against the changing and increasingly challenging environment.

This project is conducted by Professor Antonio Andreoni and Miss Sofia Torreggiani (SOAS University of London and South African Chair in Industrial Developement, University of Johannesburg) - Contacts aa155@soas.ac.uk & s_torreggiani@soas.ac.uk

Kind Regards

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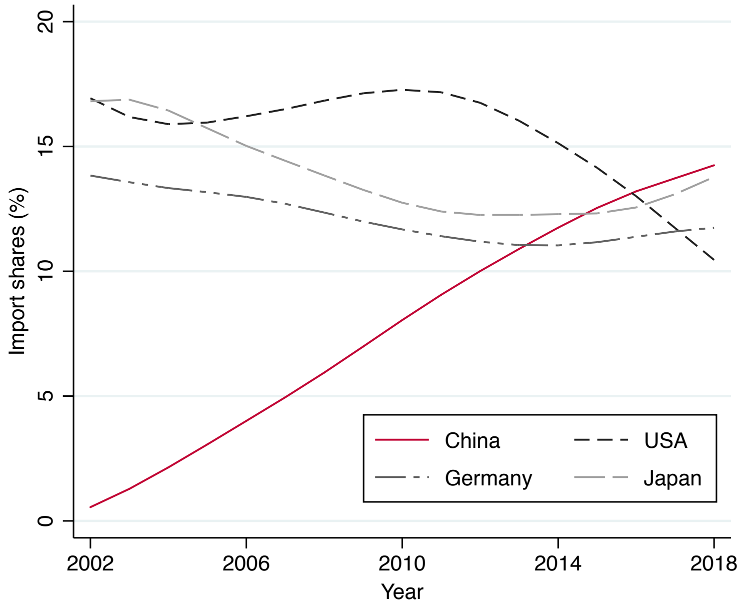
Lefapha la Dikgwebisano le Diintaseteri • Lefapha la Kgwebo le Indasteri • uMnyango wezoHwebo neZimboni • Muhasho wa zwa Mbambadzo na Indasiteri • Department van Handel en Nywerheid • Kgoro ya Kgwebo le Indasteri • Ndzawulo ya to Mabindzu na Tiindastri • LiTiko leTekuhweba netiMboni • ISebe lezoRhwebo noShishino • UmNyango wezokuRhwebelana namaBubulo

atho Pele - putting people first

Section C.3

C.3.1. Trends in world import shares in mining equipment

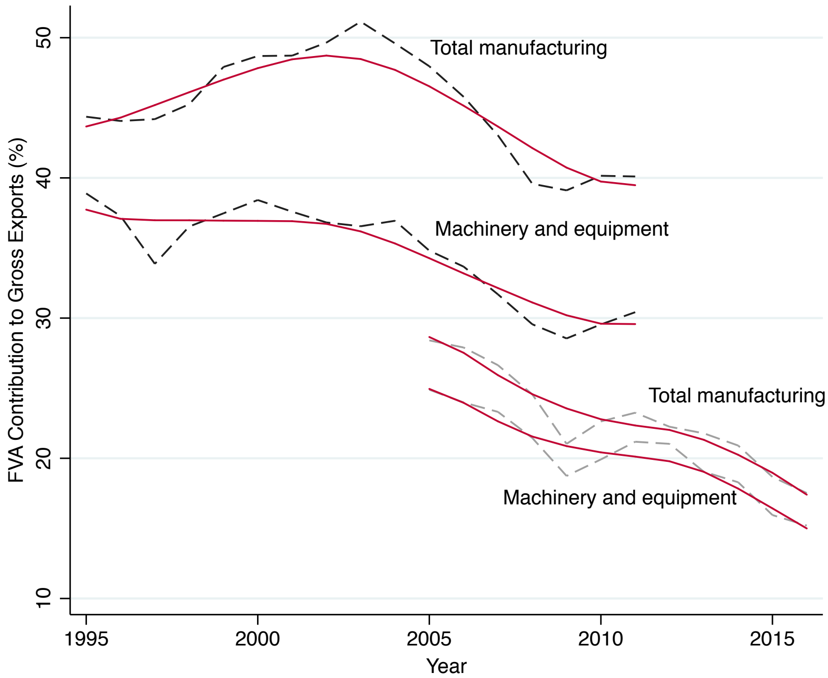
Figure C.3.1. Trends in China's share of total world imports of mining equipment (2002-2018).



Source: Own elaboration based on UN Comtrade data (UNCTAD, 2020).

C.3.2. 'In-out' pattern of China's GVC participation

Figure C.3.2. The 'in-out' industrialisation pattern in China: total manufacturing and machinery and equipment.



Notes: In red LOWESS-smoothed values.
Source: Own elaboration based on trade in value added data (OECD-TiVA, 2016 and 2018).

C.3.3. Strategic M&A and JVs by TFSs in the Chinese mining equipment industry

Table C.3.1. Selected examples of strategic M&A and JVs by TFSs in the Chinese mining equipment industry.

Company	Acquired or partner	Type	Year	Main strategic motives of M&A or JV
Caterpillar	ERA Mining Machinery	M&A	2011	Entering market for coal mining underground equipment and strengthening position in China's mid-segments.
Cummins	Liugong	JV	2011	Producing engines for the mid-market segments.
Epiroc (Atlas Copco)	Shandong Rock Drilling Tools	M&A	2013	Strengthening firm's position in the Chinese mid-market for mining consumables.
Epiroc (Atlas Copco)	Hongwuhuan Group	JV	2017	Developing, manufacturing and selling equipment for China's mining mid-market.
FLSmidth	NHI Group	JV	2016	Designing, supplying equipment for mid-market segment in China, other Asian countries, and Africa.
Metso	Quzhou Juxin Machinery, Quzhou Chixin Machinery	M&A	2013	Strengthening the firm's position in the Chinese and other markets in the Asia-Pacific area, for mining wear parts.
Metso	Shaorui Heavy Industries	M&A	2013 2019	Designing, supplying crushing and screening equipment for the mid-market segment.
Metso	LiuGong	JV	2014	Developing and supplying track-mounted mobile crushers and screens for the Chinese mid-market.
Sandvik	Shandong Energy Machinery	JV	2011	Developing road-headers for the large Chinese coal mining mid-market.
Sandvik	Shanbao	M&A	2011	Supplying mid-market buyers of basic crushers and screens worldwide.
Weir Group	Trio	M&A	2014	Providing a more complete product and service offering to existing mining customers in the China's mid-market.

Source: Own elaboration, based on interviews, companies' annual reports and specialised magazine articles.

C.3.4. Key Chinese policies in the construction and mining equipment sector

Initially, the key policy objective of the Chinese government was to establish distinctive Chinese-made brands in the construction and mining equipment mid-markets. To this purpose, a number of policy documents highlighted the need to favour the import and absorption of foreign technology, to strengthen R&D and direct financial support, to introduce preferential tax policies and to encourage the procurement of domestic equipment (CSC, 2006). More specifically, with regard to mining technologies, a comprehensive list of large excavators, dump trucks, and coal chemical and mining equipment was explicitly identified by the 11th Five Year Plan (NPC, 2006). Examples included equipment for liquefaction and gasification of coal, coal-to-alkene equipment, underground mining machines, conveyance and dressing equipment, and large open-cut mining and heavy earthmoving equipment.

Later documents focused on reducing China's dependence on the import of foreign technology and at the same time on strengthening international competitiveness, expansion in export markets and independent innovation capacity (CSC, 2008; MIIT, 2012; MOST, 2012). In this vein, the importance of additional policies, such as the improvement of tax rebate instruments, the creation of industrial clusters, support for personnel training, and encouraging financial institutions to increase export credit to support the foreign expansion of Chinese brands, was emphasised. In particular, institutes like the Exim Bank and the Chinese Development Bank were referred to as providers of such assistance.

In 2008, with the launch of the *Equipment Manufacturing Restructuring and Revitalisation Plan* (CSC, 2008) the Chinese policy focus started to shift from the creation of a group of national champions to international competitiveness, expansion of foreign market shares and independent innovation capacity. This focus on international markets was further strengthened by the fact that, due to the Chinese economic slowdown since 2011, many domestic equipment manufacturers were suffering from overcapacity and global expansion was seen as one of the ways to address this (Pepermans, 2019).

Section C.4

C.4.1. Procurement provisions in the Mining Charter

Table C.4.1. The evolution of procurement provisions of the Mining Charter (2004-2018).

Key dimension	Charter 2004	Charter 2010	Charter 2017	Charter 2018
Procurement	• Mining rights holders must commit to procure capital goods, consumables, and also services from Historically Disadvantaged South African (HDSA) companies.	• Mining rights holders must procure 40% of capital equipment from Black Economic Empowerment (BEE) entities by 2014; • Foreign multinational firms supplying capital equipment to the mining sector must devote the 0.5% of annual income generated from local mining firms to socioeconomic development programs; • Mining rights holders must procure 70% of services and 50% of consumer goods from BEE entities by 2014.	• Mining rights holders must spend 70% of total procurement spending for mining products, on South African manufactured products (with 60% of local content), broken down as follows: a. 21% of South African manufactured goods must be sourced from Black Owned companies; b. 5% South African manufactured products must be sourced from female Black Owned and/or youth Black Owned companies; c. 44% South African manufactured goods must be sourced by BEE compliant companies; • Mining rights holders must procure 100% of services from South African based firms, broken down as follows: a. 65% must be sourced from Black Owned companies; b. 10% from Black Owned female companies; c. 5% from Black Owned youth firms; • Mining rights holders must use South African companies to perform 100% of sample analysis locally; • Mining rights holders must provide proof of local content in the form of certification from SABS – suppliers of goods and services must provide local content certification.	• 70% of total mining goods must be locally procured (with at least 60% of local content), broken down as follows: a. 21% on goods manufactured by Black entrepreneurs; b. 5% on goods manufactured by BEE woman entrepreneurs or 51% on goods manufactured by youth owned enterprises, and c. 44% on goods on a BEE compliant companies; • 80% of total spend must be services from South African companies which in turn is broken down into sub-categories: a. 60% on BEE entrepreneurs; b. 10% on BEE women or 51% youth owned enterprises; c. 10% on BEE compliant companies. • 5% of a procurement budget and 10% of a services budget may be offset by investing in enterprise and supplier development programs; • 100% of samples must be analysed locally; • 70% of rights holders' R&D budget must be spent in South Africa; • Foreign suppliers must contribute 0.5% of local turnover to Mandela Mining Equipment Precinct; • Rights holders must provide annual proof of local content verification.

Source: Own summary based on DMR (2004, 2010, 2017, 2018) and Deloitte (2019).

C.4.2. A capabilities portrait of South African mining equipment producers

Table C.4.2. Capabilities of South African OEMs.

	Categories of capabilities				
Function	Investments	Product	Production process	End-market	Linkages
OEM – engineer-to-order equipment and provision of operational after-sales services	• Selection and training of workers with advanced design, product development and manufacturing engineering skills; • Reinvesting limited profits into product development and design; • No access to proprietary testing facilities and experimental spaces.	• Advanced design capabilities and related instruments (virtual simulation and rapid prototyping technologies); • Advanced problem solving, product development and manufacturing engineering capabilities; • Ability to improve design, product development and manufacturing engineering; • Advanced engineering-to-order capabilities (customisation capabilities);	• Controlling production costs (meeting price points, working capital/inventory management); • Controlling quality (at end of line/multi stage in-line) • Controlling production reliability.	• Established deep channels of communication with domestic mining houses and project houses; • Offering routine and time-based preventive maintenance; • Offering web-based condition monitoring services using manual inputs; • Developing and managing a domestic distributed network of certified support centres; • Offering free trials; • Limited marketing capabilities; • Limited selling and equipment finance capabilities.	• Managing input sourcing; • Improvement in supplier relations and cooperation for product development; • Co-investments with suppliers; • Established links to other firms and collaboration; • Participation in industry association (lobbying); • Relations with training institutes and consultants; • Still limited link to state support institutions; • Limited power to negotiate contracts with utility, service providers, large industrial suppliers; • Limited access to working capital finance • Limited access to support from intermediate technology institutes

Advanced core technological capabilities: i.e., an advanced level of technical mastery in terms of product conception, design, development *(in blue)*

Limited capabilities and resources complementary to core technological ones, needed for:

- commercialising results of innovation;
- maximising value capture from upgrading efforts and thus;
- entering into more fruitful bargaining processes with powerful chain leaders (mining houses, EPCMs, TFSs, Chinese OEMs).

Source: Own elaboration based on information gathered through interviews with industry representatives.

C.4.3. Foreign and domestic content of selected components

Table C.4.3. Selected components along the mining equipment supply chain, by foreign and domestic content.

Component	Description
Engines	Not manufactured locally, generally sourced from established suppliers in the US or Europe (or from their regional distributors located in South Africa). Key suppliers are Invicta and Italvibras for unbalanced motors, and Zest for low and medium voltage electric motors.
Bogies, axles, frames, canopies, booms, ejector, buckets	Local content is around 50%-60%, according to the specific machine under consideration. Some local OEMs produce axles in house, some international OEMs outsource the manufacture of bogie frames, rims, booms and ejector buckets to local fabricators. However, there is high import penetration for some frames, canopies and booms which require specific high-grade and specialised steel inputs that are not locally available.
Track systems	Non-trackless equipment (e.g., dozers) track manufacture is outsourced or procured internationally from suppliers such as Intertractor America Corporation.
Tires	There are some local manufacturers, but certain large tires and rims for mining trucks are often procured internationally from established suppliers.
Converters and transmission systems	High import content.
Valves, gears and hydraulic components	High import content. Suppliers used include Poclain Hydraulics and Bosch Rexroth. Some local OEMs have developed manufacturing capabilities related to hydraulic cylinders to be used in their equipment.
Control systems (on-board and remote) and instrumentation	Instrumentation has very high import content. Some local value-addition has occurred through the modification and simplification of control systems by South African OEMs. Foreign OEMs such as Sandvik and Epiroc employ their own specific automation and control systems in conjunction with inputs sourced from Parker and Nautilus International.
Others	Hoses, lights, paintwork, welding equipment, some basic grades of steel, lubricants and fuel are sourced locally.

Source: Adapted from Mintek and Turgis (2008) and CCRED (2016), based on own interviews.