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## ***Why and How Does Manufacturing Still Matter: Old Rationales, New Realities***

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### *Abstract*

The paper aims to contribute to the renaissance of a manufacturing oriented view of economic system. It begins by providing a critical review of the main turning points in the manufacturing versus services debate evaluating the analytical and empirical arguments deployed in favour of each view. It goes on to describe the profound transformations in industrial systems and the redistribution of manufacturing production across countries over the last two decades which challenge some of the assumptions on which the service oriented view is built. This section concludes by reviewing old and new rationales supporting a manufacturing oriented view. The second part of the paper addresses the importance of certain industries, including machine tools to generate industrial capability and why technological linkages stemming from manufacturing industries more generally are key enablers of a country's systemic capacity to generate technological change. Finally the negative consequences of de-linking manufacturing production from services (off-shoring) are explored highlighting the systematic disruption of the bundle of technological linkages constituting the industrial commons.

**Keywords:** manufacturing; service; industrial systems; production networks; machine tools; de-linking.

**JEL:** L16; L60; O33.

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## Introduction

Over the last three decades, the importance of manufacturing in the political economy debate has steadily declined. However, recent years have witnessed a renewed interest in manufacturing production its potential as an engine of technological dynamism and a source of the wealth of nations for which it was previously recognised. This has led analysts to identify a worldwide ‘manufacturing renaissance’ emerging in different contexts with multiple focuses, observable in many white papers and scientific research. In particular, deindustrialisation, loss of strategic manufacturing industries, increasing trade imbalances, decreasing technological dynamism and industrial competitiveness have been major concerns in advanced economies. This paper aims to contribute to the renaissance of a *manufacturing oriented view* in two ways.

The first contribution of the paper is to provide a critical review of the main turning points in the manufacturing versus services debate and evaluate the analytical and empirical arguments supporting the two opposing views. By sketching the tensions behind the service oriented view that have arisen as a result of the profound transformations in industrial systems and the redistribution of manufacturing production across countries over the last two decades (the current financial crisis and resulting manufacturing loss being just the peak of these global trends), a systematisation of old and new rationales supporting a manufacturing oriented view is presented.

Many of the rationales put forward in the current debate would have been familiar in the 1960s and 1970s but are now supported by new empirical evidence. However detailed understanding of ‘how’ and ‘why’ manufacturing matters is still limited. There are two main reasons for this insufficiency. Firstly, without disaggregating the analysis from the macro level to the sub-sectors and even production activities/tasks levels, it is difficult to say whether certain manufacturing industries matter more than others (still less why and how). Secondly, without taking into account the new realities of manufacturing systems and their configuration in global production networks, we are not able to identify the fundamental channels through which certain manufacturing industries perform their ‘catalytic role’. Disentangling these new realities and, thus, identifying the new manufacturing oriented rationales, make an integration of economics, engineering and operations management necessary.

The second contribution of the paper is to explore the reasons why certain manufacturing industries (such as the machine tools industry) are more important than others and why technological linkages stemming from manufacturing industries are key enablers of a country’s systemic capacity to generate technological change. This second issue is addressed by analysing the negative consequences of de-linking manufacturing production from services (off-shoring) which systematically disrupt the bundle of technological linkages constituting the industrial commons.

## 1. ‘Making’ or ‘doing’: Moving the debate forward

Does the wealth of nations, that is, their socio-economic development and technological power, mainly result from superior capacities in manufacturing (i.e. *making* things) or in *doing* other activities (i.e. providing services)? Furthermore, do different *sectors* and/or *production tasks* performed within each sector contribute to economic growth in specific ways? Finally, to what extent can a sustained process of economic growth rely on the increasing relative expansion of the service sector?

During the second half of the twentieth century, the political economy debate addressing these questions has witnessed two major turning points. Until the late 1970s, the debate was dominated by scholars working in the classical economics tradition who supported what we call here a *manufacturing oriented view*. Then, in the subsequent two decades of the twentieth century (1980s – 2000) a *service oriented view* came to dominate and remained central to the academic and policy debate until the recent financial crisis. These two opposing views emerged in, and may partially reflect, the worldwide process of structural change and manufacturing development that started after the World War II. A snapshot of countries’ manufacturing development trajectories over the last half of the twentieth century, is essential to understand the context of the manufacturing versus services debate.

### 1.1 Manufacturing development: Some long-term stylised facts

Eighteenth-century Great Britain was the first country to experience wide ranging and systematic manufacturing development with consequent rises in productivity and output. In the nineteenth century Belgium, Switzerland and France followed by the United States began to industrialise. In due course latecomers including Germany, Russia and Japan joined the industrialising nations, while the developing world (both colonies and non-colonies) remained oriented towards primary production (Gerschenkron, 1962; Maddison, 2007). This situation remained basically unchanged until the World War II, with the partial exceptions of Argentina, Brazil and South Africa. This group took the opportunity to start their own manufacturing development process through import substitution because of the contraction of world trade during the Great Depression (1930s).

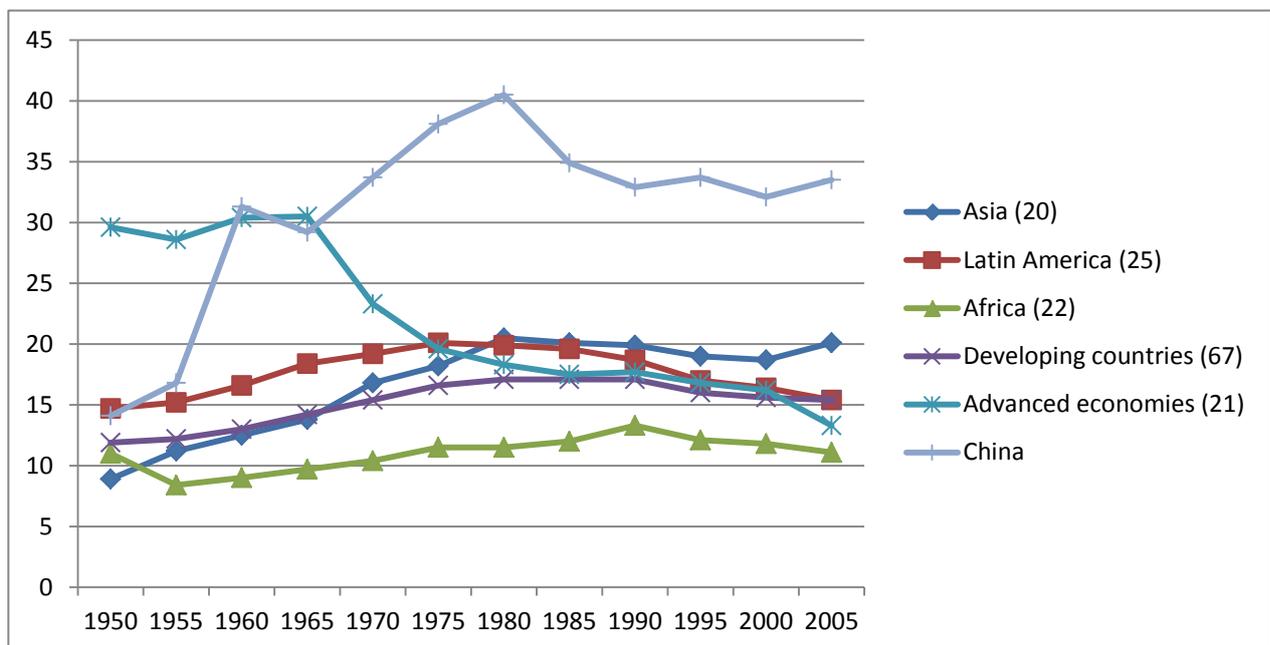
After World War II more countries began to enter the ‘catch-up phase’ thanks to the increasing advantages of backwardness, the greater opportunities for technology transfer and the industrial policies implemented by *developmental states*. This allowed them to enter the worldwide manufacturing development race (Wade, 1990; Chang, 1994 and 2002; Amsden, 2001 and 2007; Reinert, 2007). At a first glance, three sets of stylised facts emerge as characteristic features of the last half of the twentieth century.

First, there has been a worldwide process of structural change and *quantitative redistribution* of manufacturing across countries. In 1950, when the manufacturing development process became a major worldwide phenomenon, manufacturing constituted around 30 per cent of GDP in advanced economies while in developing countries the figure was around 12 per cent

(see Figure 1). Among economies in the ‘catch up phase’ Latin America remained the most industrialised region until 1975 when the manufacturing sector started contracting to the point that, in 2005, the share of manufacturing in GDP had reverted to 1950s levels. The manufacturing development path followed by countries in Africa was on average almost flat, reaching its peak in 1990 and decreasing to 11 per cent (again a return to figures seen in 1950).

In contrast manufacturing continued to increase in many Asian economies throughout the last half-century with an impressive acceleration from 1965 to 1980. Finally, in the most advanced economies, the manufacturing share started decreasing in the late 1960s, from 30 per cent to 18 per cent on average in less than a decade, although the absolute manufacturing output increases or remained stable (Maddison 2007; Szirmai 2011). During the second half of the last century, few East Asian economies experienced a sustained catching up process responsible for the quantitative redistribution of world manufacturing value added shares and world manufactures trade. In 2010 the three most successful countries in East Asia, namely China, The Republic of Korea and China Taiwan Province taken as a whole accounted for one fifth of world manufacturing value added shares and world manufactures trade.

**Figure 1: Worldwide manufacturing development paths (changes in the shares of manufacturing in GDP at current prices per country groups over the period 1950 – 2005)**



Source: Authors (based on Szirmai 2011’s database).

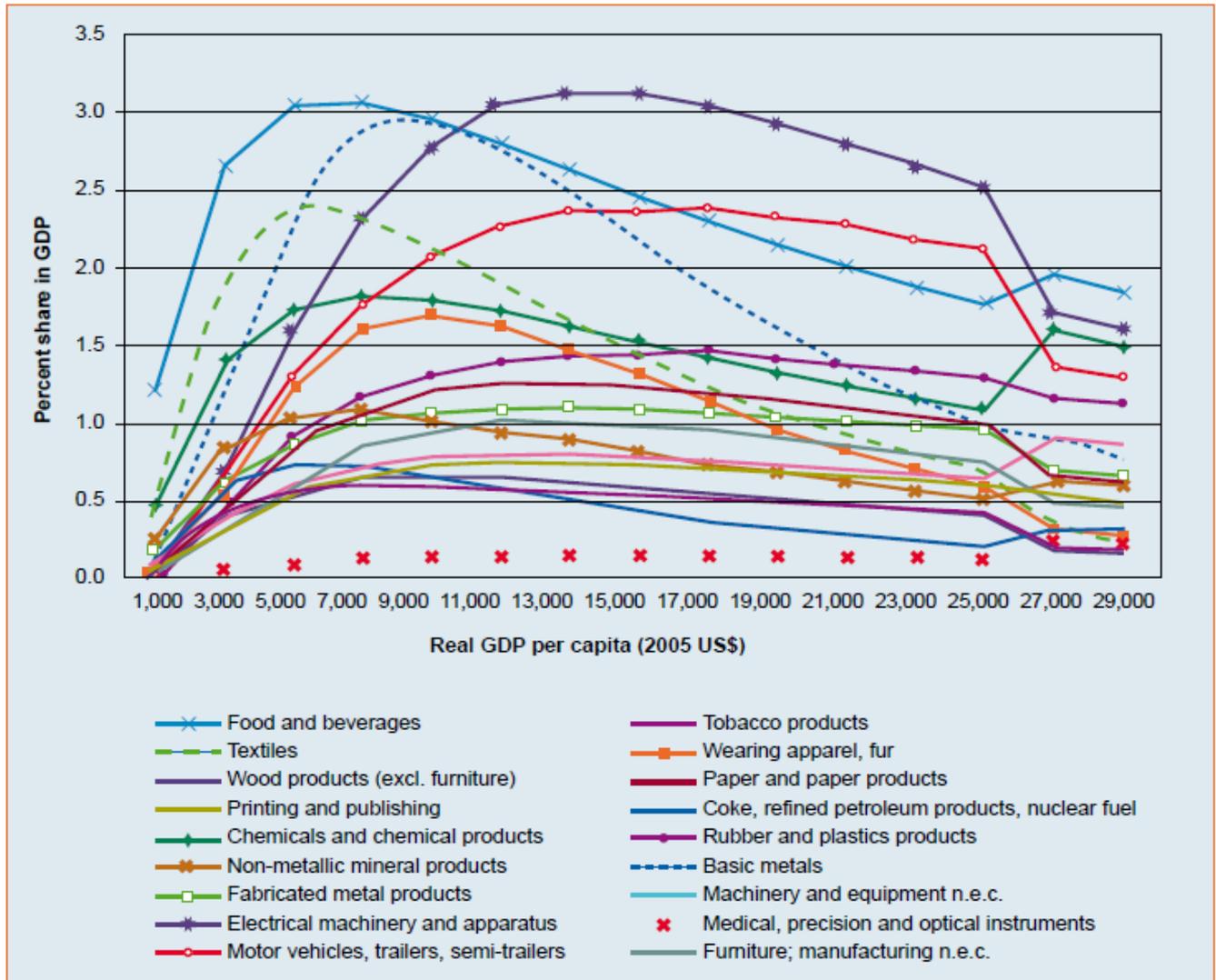
The quantitative redistribution of manufacturing, from advanced economies to a number of fast growing countries, has also been accompanied by a *qualitative transformation* within

countries' manufacturing sectors. At different stages of development (measured in real GDP per capita, US dollars 2005), a country's manufacturing sector is composed of different proportions of resource-based, labour intensive and skill/capital intensive industries. A set of regularities have been observed (UNIDO 2013):

- Up to US\$ 2000 a country's manufacturing sector tends to be composed of almost 50 per cent resource-based industries, 20 per cent labour intensive industries and 30 per cent skill/capital intensive industries;
- Between US\$ 2000 and US\$ 8000 the ratio of labour intensive and skill/capital intensive industries tends to invert, while resource-based manufacturing industries are unchanged;
- Finally, from US\$ 8000 onwards there is a tendency for the resource-based industries to become less prevalent while there is an increase in skill/capital intensive industries (such as machinery production, automotive or chemicals) and a strong reduction in labour intensive industries (such as textiles and apparel).

An analysis at the sub-sectoral level confirms the existence of qualitative transformations within the manufacturing sector as countries increase their GDP per capita (see Figure 2). Now, as Lall notes, "there are many roads to heaven" (Lall, 2004:7) and the speed at which countries go through qualitative transformations varies over time depending on the pace of their respective technological changes. However these analyses clearly suggest that while different manufacturing development trajectories are possible, some of them are more likely to occur at certain stages of development than others (see Figure 2).

**Figure 2: Change in share of manufacturing sub-sectors in GDP at selected per capita income levels for large countries**



Source: Haraguchi and Rezonja, 2010; UNIDO 4digit Database.

The third feature of the last half of the twentieth century is that the degree of *variance* among manufacturing development paths is very high even between countries within the same regions or income groups. For example, among the group of today's advanced economies, we observe two different groups of countries. There are those such as Germany and Japan which have maintained a strong manufacturing base and there are those such as the US and UK who have increasingly relied on services (O'Sullivan et al. 2013). The manufacturing development trajectories followed by China and India or Brazil are also very different.

## 1.2 The manufacturing oriented view

For a long time, the term *industrialisation* (i.e raising share of manufacturing in GDP) was synonymous with development, particularly amongst classical development economists such as Roseinstein-Rodan, Hirschman, Prebisch and Kaldor. Participation in the global industrialisation race was regarded as a *sine qua non* for countries that wished to experience accelerated economic growth, increasing labour productivity and socio-economic welfare improvements.

During the 1960s, the historical evidence available pointed to the existence of a solid correlation between manufacturing development and economic growth. Classical development economists provided two sets of explanations for manufacturing being the engine of economic growth. The first one focused on the internal ‘special properties’ of manufacturing and the second on the way in which these ‘special properties’ spread to the rest of the economy triggering processes of increasing returns and economic growth<sup>2</sup>. The systematisation of a *manufacturing oriented view* was mainly due to the seminal work of Nicholas Kaldor and Albert Hirschman (amongst others).

Building on the classical work on increasing returns by Allyn Young (1928) and the empirical regularities pointed out by Kuznets, Chenery and Syrquin, Nicholas Kaldor (1966, 1967 and 1985) developed his three famous *Growth Laws*. These showed the existence of increasing returns within manufacturing and the reasons why manufacturing was the engine of aggregate growth. The first of these laws states that the faster the rate of manufacturing growth, the faster the rate of economic growth of the overall system. The second law (also known as the Verdoorn’s law) states that there is a strong positive causal relation between the rate of growth of manufacturing output and the rate of growth of manufacturing productivity<sup>3</sup>. Finally, according to the third law, aggregate productivity growth is positively associated with the growth of employment in manufacturing (and negatively related with the growth of non-manufacturing employment).

The ‘special properties’ (implicit in the second law) that make manufacturing more effective in triggering growth of the overall economy than other types of economic activity (through the working of the first and third law) are threefold. Firstly, there are relatively broader opportunities for capital accumulation and intensification in manufacturing (in comparison to agriculture and services). Secondly, there are greater possibilities of exploiting economies of scale induced by large-scale production and technical indivisibilities, both within and across industries. Finally there are the higher learning opportunities in manufacturing production through which embodied and disembodied technological progress is generated. Given these special properties, specialisation in manufacturing implies a *double productivity gain* (it allows countries to get a ‘structural change bonus’ and to avoid a ‘structural change burden’). The former results from transferring labour from agriculture to manufacturing, the latter

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<sup>2</sup> The different sources of increasing returns identified in the classical line of Smith, Babbage, Young and Kaldor are discussed in Andreoni and Scazzieri (2013). See Toner (1999) for a review of Kaldor’s laws and their contributions to the Cumulative Causation Theory

<sup>3</sup> This law is implicit in the idea stated by A.Young (1928) that “the division of labour depends upon the extent of the market, but the extent of the market depends upon the division of labour”. This means that “an increase in the market triggers further specialisation which is a process that simultaneously increases the size of the market for specialist skills and activities” (Best 1999:107).

relates to the so-called ‘Baumol’ disease’ (an overall slowdown of productivity resulting from an over-dependence on services, especially labour intensive ones such as personal services) (Baumol 1967).

The mechanisms through which manufacturing is able to extend its special properties to the rest of the economy were explicitly formulated by Albert Hirschman (1958). In his ‘unbalanced growth model’ each sector is linked with the rest of the economic system by its direct and indirect intermediate purchase of productive inputs and sales of productive outputs – i.e. *backward and forward linkages*. According to its system of linkages, each sector exercises ‘push’ and ‘pull’ forces on the rest of the economy. Unlike agriculture, the industrial sector is characterised by both strong backward and forward linkages and thus emerges as the main driver of development<sup>4</sup>. However, sectors are not just linked through the set of physical relations of supply and demand. The embodied and disembodied knowledge generated within the manufacturing sector connects within and across sectors through so-called *spillover effects*. The latter take the form of product and process technologies (hardware) on which software-producing and software-using service sectors are based (see Szirmai, 2011). This is why, according to Hirschman (1981:75), the development process is “essentially the record of how one thing leads to another” through an incremental unfolding of production and technological linkages stemming from manufacturing production.

Economists embracing a manufacturing oriented view also stressed the importance of manufacturing in relation to other macro-economic issues. Crucially manufactured products have a high income elasticity of demand (as per capita income increases demand decreases for agricultural products and increases for manufacturing products - the so called *Engel law*, 1857). This opens up dynamic opportunities for the development of manufacturing production. Moreover, flourishing production of manufacturing tradeables was considered a fundamental condition for avoiding balance of payments crises. This was particularly the case where countries cannot rely on a high-value primary commodity export sector and the income elasticity of demand for its imports is higher than the foreign income elasticity of demand for its exports (Prebisch, 1949; Landesmann 1989).

Although the validity of Kaldor’s laws was the object of much debate throughout this period<sup>5</sup>, the manufacturing oriented view remained extremely influential until the mid-1970s. However the manufacturing oriented view came under attack during the 1980s and was gradually abandoned in the following decade when the *service oriented view* became dominant.

### 1.3 The service oriented view

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<sup>4</sup> The classical debate on agriculture vs manufacturing development is discussed in the Third Essay of this dissertation.

<sup>5</sup> Two main debates were hosted in *Economica* (1968) and in the *Economic Journal* (Rowthorn 1975). See Dasgupta and Singh (2005) for a recent empirical test of Kaldor’s laws.

The development of the service oriented view was triggered by the fact that, in both advanced and developing countries, the service sector appeared to be replacing manufacturing as the leader in the process of economic growth. Since the 1960s the most advanced economies have lost on average almost half of their manufacturing sector as a percentage of GDP as a result of an accelerated process of de-industrialisation. Moreover, in the developing world, a set of phenomena seemed to run contrary to the historical pattern of structural change followed by today's advanced countries (Palma, 2005; Dasgupta and Singh, 2005). Firstly, in several developing economies manufacturing employment (in both relative and absolute terms) started to fall early by historical standards, suggesting a form of 'premature' de-industrialisation. Secondly, the related phenomenon of 'jobless growth' appeared as even fast-growing economies, such as India, saw employment stagnation. Finally services often grew at a faster long-term rate than manufacturing during the 1990s (once again this was particularly marked in countries like India), which suggested that services can actually substitute for manufacturing as engines of growth.

Theoretical explanations for the rising share of services associated with economic growth mainly concentrate on final expenditure patterns and prices (i.e. *demand side factors*). The basic intuition is that as people increase their income they begin to demand relatively more services. The falling demand for manufacturing goods thus naturally leads (so the argument goes) to the shrinking of the manufacturing sector<sup>6</sup>. Most fundamentally, the idea that productivity increases are limited in service industries came under sustained attack with the flourishing of modern services such as finance, engineering, distribution. The increasing application of information and communication technologies (ICTs) has allowed major productivity improvements in services and the marginal cost of providing services has collapsed, showing the potential for scale effects. Those supporting the service oriented view thus questioned the notion of 'Baumol's disease'. They also emphasised the possibilities opened up by tradable knowledge-based services such as engineering, consulting and banking

Countries such as Australia, Canada, Luxembourg and the United States (but also mistakenly Switzerland and Singapore) were offered as successful examples of the huge potential contribution that the service sector can have in both employment creation (high-skilled workers in finance, business services, education and health in particular) and in productivity growth (Wolfl, 2003).

In terms of developing countries, the idea that industrialisation was no longer synonymous with development also took root and was epitomised by the Indian experience. It was suggested that developing countries now experience a historically novel pattern of structural change that is determined by a new technological paradigm. According to this explanation, services such as ICT, business support and finance are replacing or complementing manufacturing in a pro-growth way. Little emphasis is given to the fact that developing countries run the risk of premature de-industrialisation. There is little concern that this might undermine their capacity to satisfy future changes in consumer demand or to

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<sup>6</sup> See the seminal work by Fisher (1939) and Clark (1940). Bell (1973) is the classic work on post-industrial society. On income-price linkages see Kravis et. al. (1982), Bhagwati (1984a), Panagariya (1988). And finally on productivity and rising prices in services see Baumol et al. (1985)

accumulate/build production capacities and institutions. And of course this was precisely what characterised the manufacturing-led pattern of growth (see Cohen and Zysman, 1987; Rowthorn and Coutts, 2004)<sup>7</sup>.

The service oriented view resulted in a new policy package which is well summarised in the OECD *Growth in Services Report* (2005). Here the following set of policies is recommended with the explicit aim of strengthening the potential of services to foster employment, productivity and innovation:

- [1] Open domestic services markets to create new job opportunities and foster innovation and productivity.
- [2] Take unilateral and multilateral steps to open international markets to trade and investment in services.
- [3] Reform labour markets to enable employment creation and adjustment to a growing services economy.
- [4] Adapt education and training policies to rapidly changing requirements for new skills.
- [5] Adapt innovation policies to the growing importance of services innovation.
- [6] Remove impediments that prevent services firms from seizing the benefits of ICT.
- [7] Provide a fiscal environment that is conducive to the growth of services.<sup>8</sup>

Although the pro service-view remained dominant until recently, an increasing number of studies (see next section) have highlighted important fallacies in the service oriented view and the empirical evidence it offers and argued that the dichotomy between the manufacturing oriented and service oriented views itself is unhelpful.

## **2. Beyond polarisation: Sources of de-industrialisation, statistical illusions and symbiotic interdependencies**

The first issue we must address if we are to move the debate beyond the crude industry versus services dichotomy is that of the sources of deindustrialisation. We must investigate whether de-industrialisation (defined as a decline in the share of manufacturing employment in a given country) is indeed caused by the growing irrelevance of manufacturing as service oriented advocates suggest.

Robert Rowthorn and co-authors (1987; 1999; 2004) have done crucial work on the rapid process of de-industrialisation<sup>9</sup> experienced by most industrialised countries (in particular the

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<sup>7</sup> As we will argue, later developed countries may be running the same risk of losing those manufacturing capacities which are vital even for the development of their service sector.

<sup>8</sup> It is interesting to note that, in contrast, in the late 1960s, Kaldor as an economic adviser to the British government, proposed a selective employment tax to promote manufacturing in Britain.

<sup>9</sup> De-industrialisation is registered as a decline in manufacturing employment first in relative terms and then, at least in some countries, also in absolute terms.

EU and UK)<sup>10</sup> and by many medium/high-income developing countries in the 1980s and 1990s. They see this process as the “natural consequence of the industrial dynamism in an already developed economy” while “the pattern of trade specialisation among the advanced economies explains the differences in the structure of employment among them”. In other words, the main explanation of deindustrialisation is to be found in the “*systematic tendency of productivity in manufacturing to grow faster than in services*” (Rowthorn and Ramaswamy, 1999: 1-7, italics added). A recent work by Tregenna (2009: 433) confirms this thesis by demonstrating empirically that the decline in manufacturing employment is “associated primarily with falling labour intensity of manufacturing rather than an overall decline in the size or share of the manufacturing sector”.

Secondly, just as the sources of deindustrialisation seem to lie more with superior manufacturing productivity rather than strong services performance, the statistical illusion issue also runs counter to the service oriented case. The decreasing relative importance of manufacturing measured as a share of a given country’s total employment seems to be partly the result of a ‘statistical illusion’. It occurs because a number of activities from design and data processing to transport, cleaning and security have been contracted out by manufacturing firms to specialist service providers.

Even if we ignore the underestimation of manufacturing employment shares resulting from the ‘splintering effect’ (Bhagwati’s 1984b), the reality is that many OECD countries have in fact experienced a *steady* (rather than drastic) decline in the share of manufacturing in total employment (for the period 1970- 2004, see Figure 6). Thus, in contrast with what the service oriented view, deindustrialisation has not been a sudden process occurring with declines in manufacturing output, productivity and demand. Rather, employment losses have involved different industries and countries in different ways (with no exception for high tech manufacturing) (Pilat et al 2006). In the very period when deindustrialisation began (1970-2004), manufacturing production and value added in fact continued to experience strong growth and demand for manufacturing goods was sustained. Most tellingly, productivity growth in manufacturing remained high in many OECD countries while deindustrialisation was occurring and there is evidence that the manufacturing sector continued driving the process of innovation and technological change. Although the growing investment in innovative services and the outsourcing of R&D to specialised labs (counted as ‘services’) have reduced business investment in manufacturing R&D, the latter sector still accounts for the bulk of spending on technological innovation and development. The recent analysis of the structural evolution of the United States economy provided in Spence and Hlatshwayo (2011) confirms these general trends in mature industrial economies.

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<sup>10</sup> Most industrialised countries reached this phase of de-industrialisation around the end of the 1960s and the beginning of the 1970s, while some high-income DCs (such as the rapidly industrialising countries of East Asia) began this phase in the 1980s. The empirical analysis in Palma (2005) confirms the ‘inverted- U’-type of trajectory of manufacturing employment with respect to income per capita.

Given the statistical illusions discussed above (the result of a blurring of the traditional distinction between services and manufacturing), measuring intersectoral interactions is extremely complex (Pilat and Wolfl, 2005)<sup>11</sup>. The bundle of interactions that connects manufacturing and services is becoming increasingly dense, given the outsourcing of services activities from manufacturing firms to service providers but also the changing technological linkages between manufacturing and services (in particular production-related services). The existence of strong intersectoral interactions and interdependencies between manufacturing and services is something that was originally revealed by input-output analyses performed by Park (1989), Park and Chan (1989) and Park (1994)<sup>12</sup>.

It is increasingly apparent that the ‘symbiotic’ interdependencies between manufacturing and service leads to the consideration of a fundamental question, *to what extent and in which direct and indirect ways does manufacturing contribute to the development of services (and vice versa)?* The influential work by Se-Hark Park and Kenneth Chan addressed this issue by examining separately the linkages existing between disaggregated groups of services and various manufacturing industries<sup>13</sup>. Their analysis was based on the classification proposed by Gershuny and Miles (1983) which divides service activities into two major groups: marketed services and non-marketed services, and then breaks these down into further sub-categories including the sub-category of *producer services* which, in turn, is constituted by specialised technical services which support production processes.

Park and Chan’s empirical analysis conducted on 26 countries selected in the UNIDO database confirmed Hirschman’s intuition that the manufacturing sector has larger multiplier effects than do services. Specifically, it tends to generate a two to three- fold greater output impact on the economy because of the denser backward and forward linkages formed within and around it<sup>14</sup>. Moreover, their data showed the ‘catalytic role’ that industry could play in fostering employment opportunities in the services sector (the *indirect employment effect*).

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<sup>11</sup> Building on the work of Alfred Chandler, the historical analysis developed by Schmenner (2008) has shown how servitisation has antecedents that go back 150 years. At that time the bundling of manufactured goods to downstream services was a business strategy adopted by companies which lacked manufacturing strength in order to establish barriers to entry for potential competitors.

<sup>12</sup> Interestingly Damesick (1986)’s analysis of Britain transformation during the 1970s and early 1980s stressed the idea of a symbiotic relationship between manufacturing and services development (the same intuition has been empirically tested by Park, 1989).

<sup>13</sup> Empirical studies in regional income and employment multiplier analysis (Stewart and Streeten 1971) had previously shown using input-output techniques that the “the direct employment effect of industrial investment is small relative to its indirect effects resulting from the interindustry purchases of inputs and income induced effects of private consumption”. Moreover “as the industrial base broadens and becomes more integrated, both horizontally and vertically, the employment impact of industrial activities should also increase substantially” (Park and Chan, 1989: 201). This scenario is consistent with the ‘macro-economic’ effects observed by A. A. Young (1928) and later discussed in Kaldor (see above).

<sup>14</sup> The input-output analysis conducted by Pilat and Wolfl, 2005 reached the same conclusion stating that “Manufacturing industries interact much more strongly with other industries, both as providers and as users of intermediate inputs. Even though services now contribute as providers of intermediate input to the performance of other industries, their role remains more limited than that of the manufacturing sector”.

This study explicitly stressed that “the evolution of the intersectoral relationship between services and manufacturing in the course of development is symbiotic, in the sense that the growth of the service sector depends not only on that of the manufacturing sector, but also structural change of the former is bound to affect that of the latter” (Park and Chan, 1989: 212). Precisely these results have been recently confirmed by Guerrieri and Meliciani (2005). Their analysis has shown that a country’s capacity to develop its services sector depends on the specific structural/technological composition of its manufacturing sector. This is because different manufacturing industries require different producer services and tend to use them with different degrees of intensity. Their analysis also highlights how the cumulative expansion of services can follow both inter- and intra- sectoral patterns as the same service producers are also intensive users of these producer services.

Now the above mentioned studies addressed some of the misperceptions that lay behind the service oriented view and qualified and refined many of the intuitions supporting the original manufacturing oriented arguments. However, the real turning point in the ‘making versus doing’ debate was triggered by the massive acceleration in the transformations of the world manufacturing landscape resulting from the financial crisis.

### 3. The Manufacturing Loss<sup>15</sup>

The financial crisis that started in late 2007 in US had a massive impact on world industrial production, both on the total output and on the output distribution between mature industrial economies and developing countries. Focusing on the crisis period 2008-2009, we can estimate the ‘manufacturing loss’ by comparing three different scenarios (all estimates are given at constant 2000 US\$):

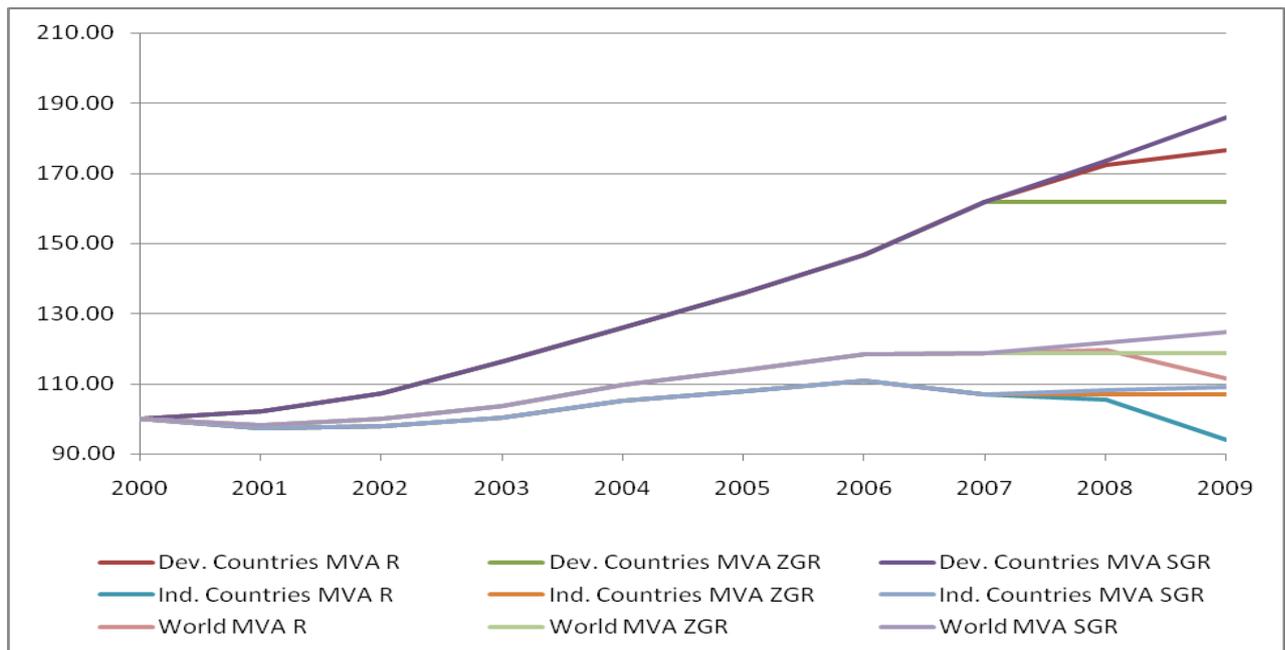
- the first scenario is the *actual* world manufacturing value added (World MVA R) during the crisis period 2008-2009;
- the second one is a *zero growth estimate* of world manufacturing value added (World MVA ZGR) for the crisis period 2008-2009;
- the third one is a *sustained growth estimate* of world manufacturing value added based on the average annual growth rate achieved in the pre-crisis period between 2000 and 2007 (World MVA SGR).

The *manufacturing loss* estimate reveals the collapse of industrial production worldwide with respect to both the zero and the sustained growth rate scenarios (see Figure 3). Specifically world manufacturing loss was US\$ 361.32 billion (with respect to the zero growth rate scenario) and US\$ 875.72 billion (if we compare it with the sustained growth rate scenario). This later figures comes to more than 1 US\$ trillion at current prices.

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<sup>15</sup> This section mainly draws on Andreoni and Uphadaya, 2013 (forthcoming).

**Figure 3: Real, Zero and Sustained Growth of MVA**



Source: Andreoni and Uphadaya, 2013; UNIDO MVA database 2011.

Now the industrialised countries in North America, Europe and Asia witnessed a severe manufacturing loss calculated to be US\$ 671.01 billion (with respect to the zero growth rate scenario) and US\$ 814.58 billion (with respect to the sustained growth rate scenario). However, in contrast, the manufacturing value added (MVA) in developing countries continued growing at least with respect to the zero growth rate scenario so there was a total *manufacturing gain* of 309.68 billion US\$. In the sustained growth estimate scenario, the manufacturing loss in developing countries was seven times more contained than that of industrialised economies (equal to US\$).125.17 billion

These results are not totally surprising if we look at these data in the context of the long term manufacturing trajectories discussed above (see section 2.1). Since 1995 developing countries' contribution to world MVA increased 13 percentage points (going from 20% to 33 %), according to UNIDO statistics. In other words, MVA has multiplied by 2.25 times. Among the developing countries, China and India drove the expansionary process, with the former becoming the world's second largest industrial power and the latter entering the top ten of world manufacturing producers for the first time.

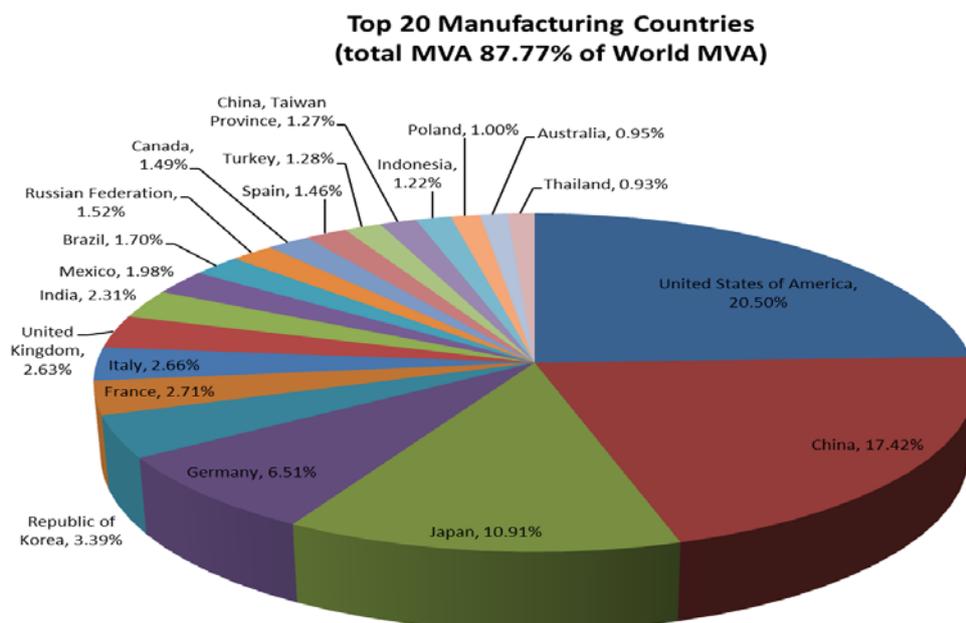
In contrast, in the case of the mature industrialised economies, the analysis seems to suggest that the financial crisis introduced a structural break in the data (although it is difficult to isolate the impact of long-term trends from the manufacturing loss experienced in the 2008-2009 period). This means that the process of sectoral re-composition that mature industrialised economies have been experiencing since the 1970s accelerated as a result of the financial crisis. The speed at which mature industrialised economies (in particular US and countries in the Euro area) have been losing manufacturing shares in GDP is remarkable. A

good way to visualise this is to look once again at the increasing relative contraction of manufacturing in favour of service sectors such as finance, real estate and business services.

After the crisis period 2008-2009, countries' performances continued to be extremely differentiated. During the period 2007 – 2012, traditional industrialised countries registered on average a significant shrinking of their manufacturing base (as measured by the fundamental industrial diagnostic, MVA per capita). The Republic of Korea is the only country among the industrialised nations that increased its MVA performance. In contrast, amongst developing countries, China and India witnessed an overall expansion of their manufacturing base. This is shown in Table 1 for a sample of countries including the top thirty performers in terms of share in world manufacturing value added and world manufactured exports for the period 2007-2012. As a result of these dynamics, the distribution of total MVA is even more concentrated if we considered that the top twenty performers in the world produce almost 90% of world total MVA (see Figure 4).

It is this dramatic acceleration in the de-industrialisation process experienced in developed countries as a result of the financial crisis that has led to an increasing questioning of the service oriented 'conventional wisdom'<sup>16</sup>. The crisis situation has led many analysts to ask: 'Has off-shoring gone too far?' and, more importantly, 'Does manufacturing still matter for the wealth of advanced nations?'

**Figure 4: Concentration of manufacturing value added, top twenty countries (2012)**



Source: Authors (based on UNIDO Statistics, 2013)

<sup>16</sup> For a comparison between the crisis rates and the pre-crisis rate of de-industrialisation see Andreoni 2013.

**Table 1: Winners and losers in a time of global financial crisis, 2007 – 2012**

Ranking 2012 by totMVA	Country	MVA var %	MVApc var %	GDP var %	GDPpc var %	MVAsh var	WMVAsh var	WGDPsh var
1	United States of America	-1.41%	-5.63%	3.01%	-1.40%	-0.61%	-1.56%	-1.19%
2	China	60.45%	56.64%	55.63%	51.94%	1.03%	5.90%	2.60%
3	Japan	-7.64%	-7.58%	-2.31%	-2.25%	-1.21%	-1.62%	-0.91%
4	Germany	-8.57%	-7.99%	3.48%	4.14%	-2.49%	-1.04%	-0.24%
5	Republic of Korea	25.22%	22.42%	15.94%	13.34%	2.07%	0.52%	0.14%
6	France	-6.56%	-9.08%	0.42%	-2.29%	-0.80%	-0.37%	-0.31%
7	Italy	-23.98%	-25.81%	-7.03%	-9.27%	-3.09%	-1.05%	-0.51%
8	United Kingdom	-14.75%	-17.33%	-3.40%	-6.33%	-1.33%	-0.64%	-0.51%
9	India	38.46%	29.17%	38.01%	28.76%	0.05%	0.54%	0.57%
10	Mexico	6.47%	0.12%	8.28%	1.82%	-0.30%	0.01%	0.01%
11	Brazil	3.83%	-0.66%	17.51%	12.44%	-1.75%	-0.04%	0.18%
12	Russian Federation	-1.56%	-1.15%	9.48%	9.94%	-1.54%	-0.12%	0.03%
13	Canada	-13.60%	-17.83%	5.48%	0.32%	-2.33%	-0.34%	-0.05%
14	Spain	-20.82%	-24.49%	-4.13%	-8.57%	-2.35%	-0.50%	-0.27%
15	Turkey	19.60%	12.35%	16.67%	9.60%	0.44%	0.14%	0.09%
16	China, Taiwan Province	6.96%	5.30%	11.14%	9.42%	-0.99%	0.01%	0.02%
17	Indonesia	26.73%	20.36%	32.97%	26.29%	-1.26%	0.20%	0.15%
18	Poland	37.37%	36.91%	18.54%	18.15%	3.00%	0.23%	0.07%
19	Australia	4.44%	-3.76%	12.20%	3.39%	-0.68%	-0.01%	0.07%
20	Thailand	20.48%	16.87%	13.99%	10.57%	2.01%	0.11%	0.02%
21	Netherlands	-6.65%	-8.17%	0.49%	-1.14%	-0.92%	-0.13%	-0.09%
22	Switzerland	3.71%	0.87%	5.77%	2.87%	-0.37%	-0.02%	-0.02%
23	Sweden	-0.52%	-4.02%	4.67%	0.99%	-0.89%	-0.05%	-0.02%
24	Austria	-2.13%	-3.51%	3.43%	1.97%	-1.03%	-0.06%	-0.03%
25	Argentina	24.89%	19.57%	31.26%	25.67%	-1.04%	0.10%	0.09%
26	Belgium	-7.17%	-9.32%	2.14%	-0.22%	-1.39%	-0.09%	-0.04%
27	Ireland	21.30%	13.67%	-8.54%	-14.29%	6.44%	0.08%	-0.07%
28	Malaysia	12.33%	3.63%	21.24%	11.85%	-2.12%	0.03%	0.04%
29	Singapore	23.33%	7.59%	23.74%	7.94%	-0.08%	0.07%	0.04%
30	South Africa	1.49%	-2.30%	11.06%	6.91%	-1.43%	-0.02%	0.02%
	<b>World &lt;YB 2013&gt;</b>	6.09%	0.24%	7.84%	1.90%	-0.28%	0.00%	0.00%
	<b>Industrialized Economies</b>	-4.99%	-7.75%	1.89%	-1.06%	-1.08%	-7.58%	-4.24%
	<b>Developing &amp; EIE</b>	35.45%	27.24%	27.62%	19.88%	1.24%	7.58%	4.24%

Source: Authors (based on UNIDO Statistics, 2013)

#### 4. *Why and how does Manufacturing still matter: Old rationales, New realities*

Since the 2009 crisis there has been a proliferation of policy reports, academic contributions, manufacturing national strategies and white papers in all major industrialised economies, investigating if manufacturing still matters<sup>17</sup>. After having lost 41% of its manufacturing jobs in thirty years, the US is today among the most active players in shaping a *new manufacturing oriented view*. This is rooted in the following arguments:

- (i) Manufacturing is a crucial source of *high quality employment* (in US, during the period 2008-2010, it was estimated that earnings in manufacturing are some 20% higher than earnings in non-manufacturing industries - see Helper et al. 2012).
- (ii) Producing tradable manufactured goods is essential to maintain the *trade balance*, given that around two-thirds of world trade is still in manufactured goods (according to UN Comtrade, the figure was 83.4% in 1996, while in 2009 it was 77.4%, of which 38% were medium tech products).
- (iii) Manufacturing is the main engine of economic growth, thanks to its *higher productivity and scope for innovation*.

Many of the rationales put forward seem like ‘old wine in new bottles’, although they are often supported by new empirical evidence. For example Rodrik (2009) found that, since 1960, developing countries economic growth’ is strongly associated with the development of modern industrial sectors (both manufacturing industries and agribusiness). Another recent empirical analysis confirmed the ‘engine of growth hypothesis’ for a sample of 90 countries (21 advanced economies and 69 developing countries) in the period 1950-2005 (Szirmai and Verspagen, 2010). This study found that the share of manufacturing is positively related to economic growth from 1950 to 2005 (in particular for poorer countries), while services have a significant positive effect only until 1990 and with coefficients far lower than those of manufacturing. Interestingly in the period 1990-2005 the coefficient for services becomes insignificant.

Old rationales and new evidence are not fully satisfactory however in addressing the ‘why’ and ‘how’ parts of the ‘does manufacturing still matter?’ question. First, without disaggregating the analysis from the country level to the sub-sectors and even production activities/tasks levels, it is difficult to say whether certain manufacturing industries matter more than others (still less why and how). Secondly, without taking into account the new manufacturing production activities, we are not able to identify the fundamental channels through which certain manufacturing industries perform their ‘catalytic role’ (the expression is from the input-output analysis of manufacturing-services linkages by Park and Chan, 1989). In this respect, increasing doubt has been cast on the claim that the ‘physical’ intersectoral linkages are still the main vectors through which manufacturing pulls overall economic development forward. Thus we explore the kind of linkages that make manufacturing central for economic dynamism.

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<sup>17</sup> See among the others: Tasse, 2010; Pisano and Shy, 2009 and 2012; Ettliger and Gordon, 2011; Ezell and Atkinson, 2011; Helper, et al. 2012; Bianchi and Labory 2011.

The following two sections address the reasons why certain manufacturing industries are more important than others and why technological linkages stemming from manufacturing industries are key enablers of a country's systemic capacity to generate technological change. First, we argue that the development of a new manufacturing oriented view should focus on the crucial role played by certain 'mother industries' (as the machine tool industries are called). In the second section, we investigate the systemic technological linkages which affect the scope for innovation of the overall economic system. This second issue is going to be addressed by analysing the negative consequences of de-linking manufacturing production from services (off-shoring) which systematically disrupt the bundle of technological linkages constituting the industrial commons.

#### **4.1 The manufacturing engine: 'The production of machines by means of machines'**

The machine tool industry is a sub-sector of the mechanical engineering industry. Machine tools are known as 'mother machines' because they enable the production of other machines and equipment (within the broader mechanical engineering industry), including themselves. There are various reasons why machine tool industries are at the very core of the manufacturing engine (Fransman 1986). Firstly, machinery producers have a unique capacity of 'self-reproducing themselves' that is, the capacity of manufacturing their own machines (CECIMO, 2011). Secondly, the fact that machine tools critically enable cost reductions, quality improvements and productivity increases, and reduction in set-up production times. Thirdly, machine tools have a wide range of applications in major industries (such as mechanical engineering and construction, computers, automotive and aerospace, wind turbines and satellite and all manufacturing processes involving metals).

The relevance of these characteristics was documented by Nathan Rosenberg (1963) in his historical analysis of the machine tools industry. His very comprehensive study began with the emergence of the first specialised producers of machine tools (from 1840 to 1910. By 1910, 82.4% per cent of the world production of machine tools was concentrated in three countries: the US (50%), Germany (20.6%) and the United Kingdom (11.8%)<sup>18</sup>. The historical account provided by Rosenberg provides crucial evidence demonstrating why and how countries' manufacturing development trajectories were driven mainly by their machine tools industry. Among the multiple ways through which machine tool industries introduced and spread technical change, Rosenberg (1963:416) identified three key mechanisms.

Firstly, what he calls the 'external adaptation' principle. According to this principle "all innovations – whether they include the introduction of a new product or provide a cheaper way of producing an existing product – require that the capital goods sector shall in turn

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<sup>18</sup> In 1925 the same three countries still dominated the 84.3% of world machinery production. These data are taken from Dr Karl Lange memorandum presented in May 1927 at the League of Nations International Economic Conference. As stressed in the journal *Mechanical Engineering* (1928:285) Lange's work is "the first analysis of the machinery industry of the world that has been published". After the World War II, the situation remained almost unchanged, although the USSR entered the machine tool industry global race reaching 10% of world production (Rynn, 2010).

produce a new product (capital good) according to certain specification” (1963:416). Indeed, machine tools producers are requested to continuously customise their production and develop innovative solutions for more efficient production systems, often joining forces with their customers in the consumer goods or other capital goods industries. In doing so, machine tools producers operate as ‘innovation bridges’. In other words, they transfer production expertise and transform the way in which goods are produced and services are delivered.

Secondly, the ‘internal adaptation’ principle, refers to the unique possibility for machinery producers to improve and change the characteristics/specifications/standards of the capital goods they produce by improving and changing the machines used for the production of the capital goods themselves. Cost-reduction in the machine tool industry triggers a cumulative process through which investment activities in other industries are boosted, the speed at which technological innovations are installed and spread increases, and the marginal efficiency of capital of other industries rises. Finally, for the economy as whole, cost reductions in the machine tools industry is a form of capital saving.

The third principle is that of ‘external economy’. According to Rosenberg, the “high degree of specialisation [in machinery production] is conducive not only to an effective learning process but to an effective *application* of that which is learned. This highly developed facility in the designing and production of specialised machinery is, perhaps, the most important single characteristic of a well-developed capital goods industry and constitutes an external economy of enormous importance to other sectors of the economy” (Rosenberg, 1963:425; see also Andreoni, 2013).

The machine tool industry underwent profound transformations through the twentieth century. Initially, the introduction of numerical control (NC) machine tools improved flexibility, allowed automation and reduced costs. Later increasingly refined computerised numerical control (CNC) machines, as well as computer-aided design (CAD) and computer-aided manufacturing (CAM) offered efficiency gains in material consumption, shortened the period between the design and the production process, and allowed the increasing control of complex production systems (Mazzoleni, 1997; Arnold 2001). Despite these changes, the three mechanisms identified by Rosenberg as making the machine tool industry ‘special’ still stand and indeed their scope is broadened. The machine tool industry increasingly enables the working of complex production systems in which the traditional manufacturing tasks are intertwined with service activities and new technologies. This has been widely documented in technical reports produced by the European network of machine tools producers<sup>19</sup>.

These reports explain how machine tools “enable to transfer the latest technological developments in information and communication technologies or material sciences into production systems, which allow to increase the efficiency of the production process and to machine new materials which are used later in new fields of application” (CECIMO 2011:12;

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<sup>19</sup> CECIMO was founded in 1950 and currently covers almost the entire metalworking machine tool production industry in Europe and a third of worldwide firms. It has as members approximately 1500 companies (over 80% of these are SMEs) with a total number of 150.000 employed people. The turnover in 2011 was approximately 21 billion euros and  $\frac{3}{4}$  of the production was shipped outside CECIMO region (the latter including EU, EFTA and Turkey).

see also the Thematic Report on *Key Enabling Technologies* produced by the Working Team on Advanced Manufacturing Systems, 2010). The machine tools industry also facilitates the accumulation of engineering expertise that cannot be easily copied/reproduced by competitors. This guarantees a certain competitive advantage to producers in international markets and a ‘first mover’ advantage in the development of future products and processes.

As a result of these unique characteristics much evidence can be found, throughout the last century, in support of the claim that those countries that saw their machine tools sector go into decline found they had an increasingly reduced capacity to make goods. By the same token these same countries which saw falls in manufacturing output were also those where the remaining manufacturing output became increasingly dependent on the import of ‘machines for making goods’. Among the major industrial economies those countries which underwent a profound process of de-industrialisation in the second half of the last century were also those who lost the higher shares in world machine tool production. The United States went from 26.6 per cent in 1980 to 11.7 per cent of world machine tool production in 1995 (the United Kingdom lost its major role before the 1980s, and in 1995 accounted for less than 3 per cent of world production). In contrast Japan and Germany followed the opposite trend during the same period, going from 14.3 to 23.5% and from 17.6 to 22.6% respectively (Rynn, 2010).

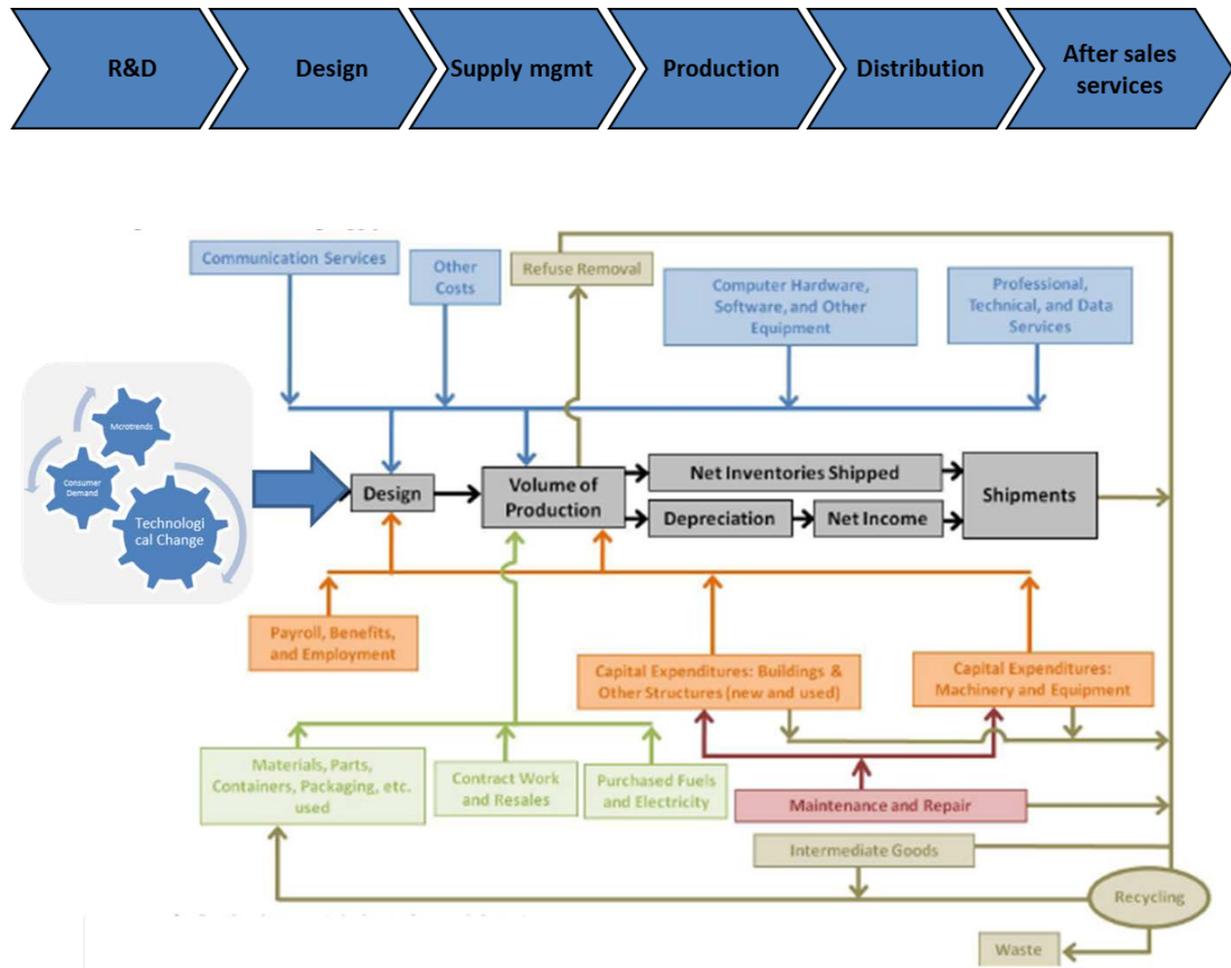
In 2010 one-third of world machine tool production was concentrated in China and another third in the Euro area (the three major producers are Germany with 43.5%, Italy with 23% and Switzerland with 11%, of total European, CECIMO database). Meanwhile Japan still controls 14%, followed by the Republic of Korea with 7% and Taiwan with 6%. As of 2010 the United States accounted for only 4% of global production. A full 66% of the machine tools produced in 2010 were consumed in Asia, 21% in Europe and 13% in America. In 2011 China alone accounted for 45% of world machine tool consumption. It was followed by three major net exporters (Japan, Germany and Italy which consumed 9, 8 and 4 percent respectively) and one major importer, the United States, with an 8% share in world machine tool consumption (Oxford Economics, 2012). According to the CECIMO forecast, machine tool consumption will continue shifting to Asia which will reach 70% of world total in 2015, confirming Asia as the major consumer and producer of machine tools.

#### **4.2 Breaking technological linkages in the manufacturing value chain: Losing industrial commons and technological lock-in**

Modern definitions of manufacturing increasingly recognise the ‘value chain’ of activities from R&D to after-sales service (see Figure 5) This value chain representation highlights potential interdependencies between the stages. Whilst varying significantly between sectors and technologies these interdependencies can dramatically influence companies and indeed countries opportunities to capture value from their innovations, capabilities and market opportunities. Loss of production capability for example, may make it impossible to realise a new product concept while poor understanding of production and supply may mean that new

product designs are infeasible. Indeed product innovations themselves may be inhibited by the loss of opportunity to iterate product and process synergies.

Figure 5: The Manufacturing value chain



Source: Authors (adapted from NIST, 2013:8)

After two decades (from the 1980s to the late 1990s)<sup>20</sup> in which the farming out/abroad of in-house operations occurred with almost religious fervour, more recent attitudes have been cautious and even fearful of their consequences. The dominant view implied that “by shedding assets, companies can be born again as product designers, solutions providers, industry innovators, or supply chain integrators”. They can thus “dump operational headaches and bottlenecks downstream, often capture immediate cost savings, and avoid labour conflicts and management deficiencies” (Doig et al. 2001, p. 24). However, in many industries such as automotives, electronics and software, it has been observed that companies

<sup>20</sup> According to *The 1999 Outsourcing Trends Report*, the outsourcing of operations and facilities across industries rose by 18 percent only in the period from 1999 to 2000.

which outsourcing too much run the risk of ceding and, sometimes, even destroying those capabilities and processes that have constituted their competitive advantages. Moreover, outsourcing companies fail to capture the innovation opportunities that reside in the spaces of interaction and interfaces between manufacturing production and production related services (Quinn and Hilmer, 1995). In sum, there is considerable evidence that many companies have *overestimated* the advantages of outsourcing and offshoring and *underestimated* problems, such as dealing with inventory, obsolescence, organisational traumas, reaching quality standards and maintaining in-house technological capabilities (Ritter and Sternfels, 2004).

The relocation of manufacturing firms and/or service providers to other countries triggers two simultaneous processes which affect outsourcers' production and technological structures. First, countries relocating the major part of their manufacturing activities tend to experience a process of industrial commons deterioration, increasing relocation of production related services and technological lock-in. Second, in contrast, those countries in which production is relocated experience an expansion of the manufacturing sector and an increasing co-location of other manufacturing firms (as well as production related services providers). The transformation in the US software industry demonstrates this point well. In order to lower software development costs US companies initially started outsourcing mundane code-writing projects to Indian firms<sup>21</sup>. However Indian companies soon developed their technological capabilities in software engineering because of the experience provided by the routine work they had been given. Thus India became increasingly able to attract more complex manufacturing and services activities to India such as developing architectural specifications and writing sophisticated firmware and device drivers (Pisano and Shih, 2009 and 2012; Tasse, 2010).

The opposite trend, namely loss of technological capabilities has been observed in US software companies. Of course a similar process may be triggered by off-shoring services providers as well as manufacturing firms. However, given the multiplier effects which characterise the expansion of the manufacturing base and the fact that certain services (especially production-related services) have to remain near production sites, it seems that off-shoring manufacturing activities is strategically more damaging than losing service-providers.

These cumulative processes of relocation and co-location are responsible for the transformation of the productive and technological structures of countries and for the present and future prospects of innovation and specialisation of private companies. For example, as a result of outsourcing, the U.S. industrial structure is no longer able to manufacture many of the cutting-edge products it invented. As has been widely documented “[a]mong these are

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<sup>21</sup> Apple is a well-known exception. Although it has outsourced the manufacture of its notebooks, iPod, and iPhone, Apple has preserved in-house technological capabilities by remaining involved in key phases of the production process. It still plays the major role in the selection of components, industrial design, software development as well as direct interaction with users (i.e. ‘learning by using’).

such critical components as light-emitting diodes for the next generation of energy-efficient illumination; advanced displays for mobile phones and new consumer electronics products like Amazon's Kindle e-reader". They also include "the batteries that power electric and hybrid cars; flat-panel displays for TVs, computers, and handheld devices; and many of the carbon-fibre components for Boeing's new 787 Dreamliner" (Pisano and Shih, 2009:116).

In contrast there is mounting evidence that countries acquiring manufacturing production and developing production-related services are accumulating technological capabilities and increasingly benefitting from the relocation and co-location of companies at all stages of global value chains. By 2010, Fortune 500 companies have 98 R&D centres in China and 63 in India. Surprisingly, IBM employs more people in the developing world than in America while in 2008, the Chinese telecom giant Huawei applied for more international patents than any other firm in the world (Cataneo et al. 2010). In fact by some estimates as much as 90% of electronics research and development now takes place in Asia (McCormack, 2009).

Pisano and Shih (2009) have done important research on the semiconductor, electronics, pharmaceutical and biotech industries. This has revealed how the production and innovation capacities of a given economic system depend on the presence of multiple resources such as R&D know-how, engineering skills, technological capabilities, and specific manufacturing and prototyping competences. Many of these resources are embedded in a large number of manufacturing and services companies as well as other organisations, typically universities and vocational schools. The co-location of these actors means that the same companies and institutions can have access to their resources. This is the root of the *industrial commons* phenomenon<sup>22</sup>. As in almost all high-tech industries, product and process innovations are strongly intertwined. The fact that manufacturing firms can undertake daily interactions with other manufacturers and the providers of production related-services locally constitutes a source of competitive advantage which benefits all actors involved (i.e. *industrial commons*)<sup>23</sup>. It is important to stress that even the development of high-tech cutting-edge products often depend (amongst other factors) on the commons of a mature manufacturing industry. The deterioration of the industrial commons caused by outsourcing can, in the long-run, affect the ability of a given economic system to introduce new products. This is because the suppliers, skills and services required to set up a new enterprise are no longer available locally. In contrast, countries in which manufacturing and services activities co-locate will experience processes of industrial commons development and benefit from innovation opportunities arising at the manufacturing-services interfaces.

The second dynamic related to the de-linking of manufacturing and services in global value chains is that of technological lock-in. This refers to macro-level forces that create systematic barriers to the diffusion and adoption of efficient technologies (Arthur, 1989). One of the major factors associated with technological lock-in is the idea of increasing returns to

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<sup>22</sup> The idea of industrial commons is rooted in the classical work on industrial districts (Marshall, 1920) and the work by Michael Best in Greater Boston.

<sup>23</sup> Coffey and Bailly (1991, p.109) emphasise the role of co-location stressing how "it is the cost of maintaining face-to-face contacts between the producer on the one hand, and their inputs and markets, on the other hand, that is potentially the most expensive element of intermediate-demand service production".

adoption. Early adoption of a technological solution might give it enough edge to secure its dominance in the market. Even if an improved technology (e.g. more environmentally efficient) is developed, such increasing returns may keep them locked-out of the market (i.e. it doesn't pay off to change production). These technological lock-in dynamics explain the continued dominance of the QWERTY keyboard over the Dvorak Simplified Keyboard (David, 1985), and the VHS video cassette recorder standard over Betamax (Arthur, 1994).

Recent work has shown that manufacturing offshoring can lead to technological lock-in effects. Fuchs and Kirchain (2010) explain that, as production in the optoelectronics industry has been outsourced to East Asia, the manufacture of better-performing designs developed in the US no longer pay off. "Production characteristics are different abroad, and the prevailing design can be more cost-effective in developing country production environments" (Fuchs & Kirchain, 2010). Thus they conclude that offshoring reduces incentives to innovation and can therefore lead to an erosion of technological competitiveness.

The potential consequences of technological lock-in have been increasingly attracting attention among academics and policymakers. Their concern not only focuses on the potential adverse consequences of the loss of production capacity within advanced countries, but also on the potential loss of technology dynamisms and competitiveness in global industrial systems as a whole.

### **Concluding remarks**

This paper has provided a critical review of the main turning points in the manufacturing versus services debate and has evaluated the broad theoretical, empirical and policy landscape within which the manufacturing renaissance is appearing. The review of the manufacturing oriented versus service oriented debate showed how, over the latter part of the XX century, the polarisation of the debate seriously undervalued the role of manufacturing development. As a result of the financial crisis and the massive manufacturing loss experienced by developed economies many have started to question "Why and how does manufacturing still matters?".

The paper argued that the answer to this question cannot be found in conventional macroeconomic or sector level analyses, instead it is necessary to look at the sub-sectors and even production activities/tasks levels, taking into account the new realities of manufacturing systems and their configuration in global production networks. The paper has shown the extent to which this change of perspective becomes essential if we want to understand why certain manufacturing industries are more important than others and why technological linkages stemming from manufacturing industries are key enablers of a country's systemic capacity to generate technological change.

Production equipment industries, exemplified in our paper by the analysis of the machine tool industry, serve to enhance and support wider production capability and capacity development

harnessing and embodying key technological linkages. Finally, the importance of such technological linkages has been discussed in the new context of global manufacturing value chains and companies' offshoring. The paper documented how offshoring might run the risk of breaking key innovation chains leading to technological lock-in, or perhaps better lock-out as countries lose the incentive and capability to develop and introduce new innovations and indeed products.

The set of manufacturing realities and dynamics analysed in the paper constitutes a starting point towards a new manufacturing oriented view of economic systems as well as it has profound implications for the design and governance of manufacturing policies in advanced economies.

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