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Trade Barriers or Catalysts?

Non-Tariff Measures and Firm-Level Trade Margins

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Abstract

This paper empirically examines how standards and technical regulations affect export margins in three African countries at the firm level. The approach involves combining detailed customs transaction data at the firm-product level with bilateral information on non-tariff measures within a gravity model of trade framework. The findings show standards and technical regulations have no impact on the extensive margin of firm-level trade. However, they do diminish trade at the intensive margin in both the agriculture and manufacturing sectors. Small firms are more affected at the intensive margin compared to medium and large firms, and similarly, final goods are more affected compared to inter-mediate goods. Moreover, in the manufacturing sector, firms with initially higher product quality experience a reversal of the trade-reducing effect of standards and technical regulations, whereas in the agriculture sector, this effect is less pronounced for their counterparts. The results also suggest that African exporting firms face equivalent impacts in both regional and global markets.

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Non-Tariff Measures and Firm-Level Trade Margins

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1 Introduction

Several rounds of trade negotiations and reforms have reduced tariffs globally to historically low levels (Baldwin, 2016), even more so for developing countries, including those in Africa, which often benefit from unilateral and bilateral trade preferences. Nevertheless, alongside these tariff reductions, there has been a notable surge in the adoption, scope, and application of non-tariff measures (NTMs) to regulate trade (WTO, 2012; Niu et al., 2020). NTMs encompass a broad range of regulatory and administrative measures, which are not tariffs but can affect trade flows. These include product standards, licensing requirements, customs procedures, and technical regulations (Staiger, 2019). As the GDP per capita rises, the relative contribution of NTMs in determining overall protection levels increases (WTO, 2012). In developed countries, about 70% of imports are typically subjected to NTMs, but approximately 40% in developing countries (UNCTAD and World Bank, 2018). As a result, in numerous high-income destinations, the success of exports from developing countries is more likely contingent upon compliance with NTMs.

The rapid proliferation of NTMs has sparked considerable interest in the trade literature (see e.g., Li and Beghin, 2012; Ronen, 2017). Their impact on trade is, however, ambiguous because they have the potential to influence both the demand and supply of the products that they affect. On one hand, they can signal quality and safety to consumers, thereby affecting demand. On the other hand, they might raise costs for exporters of the products they impact, affecting the supply side. In the end, their trade effects depend on the relative magnitude of their demand enhancing and trade cost effects. As a consequence, the findings from the existing literature are mixed. In addition, despite the increasing utilization of NTMs, the literature on their impact on exporters in developing countries is limited (Grundke and Moser, 2019).

In this study, we examine the impact of NTMs, specifically standards and technical regulations, on exports from Africa. To do so, we combine dis-aggregated firm-product level customs transactions panel data in three African countries (i.e., Burkina Faso, Malawi, and Senegal) and panel data on NTMs within a reduced-form gravity model. Of the different NTM types, we focus on standards and technical regulations, which are mainly sanitary and phytosanitary (SPS) and technical barriers to trade (TBT) measures.[1] While they are *prima facie* introduced to address market imperfections such as genuine health and safety concerns, they can also disguise protectionist intents including protecting domestic producers from foreign competition. For instance, the introduction of standards and technical regulations could increase both fixed (e.g. costs related to efforts devoted by firms to show compliance with the standards) and variable (e.g. costs related to substituting low-quality intermediate inputs with high-quality ones) trade costs (Ing et al., 2016; De Melo and Shepherd, 2018). In addition, standards and technical regulations could enhance trade by reducing information asymmetry between producers and consumers in terms of product safety and other product

[1] NTMs can be either technical or non-technical. Non-technical measures are only applied at the border (e.g., quantitative restrictions, import licenses, competition measures) and thus only affect third-country producers. Given their discriminatory nature, the trade effects of border NTMs are often obvious, e.g., import (export) bans will reduce imports (exports). The technical measures are behind-the-border measures that affect both domestic and foreign producers. These are mainly dominated by SPS and TBT measures.

characteristics. Hence, their impact on trade margins depends on the relative magnitude of compliance costs and the benefits derived from reducing information asymmetry, rendering it theoretically ambiguous.[2]

Our empirical results show that standards and technical regulations reduce firm-product level exports from the sample of countries used in our study. At the intensive margin, the elasticity of firm-product level exports to the count of NTMs is about 0.07%, on average. This elasticity rises to 0.13% and 0.17% in the manufacturing and agriculture sectors, respectively. At the extensive margin of export adjustment, defined as export market entry and exit, we find no effect. The latter findings, coupled with the significant effects at the intensive margin, imply that for African firms, NTMs increase more their variable costs of trade than their fixed costs. The results are also heterogeneous along multiple dimensions. In the agriculture sector, the trade reduction is driven mostly by SPS measures, while the trade reduction effects are driven by TBT measures in the manufacturing sector. Furthermore, the trade-reducing effects vary by the location of the product along the value chain, being more pronounced for final goods than for intermediate goods. These effects also decrease with firm size, with larger and medium-sized being relatively less affected compared to small firms. However, we find that the trade-reducing effects are not heterogeneous across the level of development of the destination country, and whether the export destination is within or outside Africa.

In extending our results, we assess the effects of NTMs on export volumes, prices, and product quality following Khandelwal et al. (2013). In the agriculture sector, the decrease in export values is due to lower export prices, while in the manufacturing sector, they are driven by a reduction in export volumes. Although we did not observe the product quality upgrading effects of NTMs in our sample, we find that initial product quality moderates the trade-reducing effects of NTMs. The trade-reducing effect of NTMs at the intensive margin is reversed for firms with higher initial product quality in the manufacturing sector and is less pronounced for firms with relatively high initial product quality in the agriculture sector.

Our work contributes to the literature on how standards and regulations shape firms' export strategies in developing countries in three main ways. First, we examine the relationship between technical measures and trade using firm-level data and focussing on both the agriculture and manufacturing sectors. Standards and regulations are more likely to affect the trade of firms in low-income countries, especially those in Africa because they tend to be more standard-takers rather than standard-makers. Yet, much of this research has focused on relatively more developed and emerging economies, leaving a gap in understanding the specific challenges and opportunities facing African countries.[3] Most of the existing literature on the trade effects of NTMs for African exports have predominantly done this at the country level for the agriculture sector (Otsuki et al., 2001; Czubala et al., 2009; Kareem et al., 2017; Tchakounte and Fiankor, 2021; Sanjuán López et al., 2021; Traoré and Tamini, 2022), mainly due to lack of firm-level data for these countries.[4] It is firms and not countries that largely engage in international trade (Bernard et al., 2007). Thus, our study builds upon Fernandes

[2]Going forward, we will use the terms standard-like NTMs, SPS and TBT measures, and standards and technical regulations interchangeably.

[3]See, for example case studies from France (Fontagné et al., 2015; Schmidt and Steingress, 2022; Disdier et al., 2023), China (Beestermöller et al., 2018), Colombia (Rosenow, 2024), and Peru (Curzi et al., 2020).

[4]Santeramo and Lamonaca (2019) offer a review of this literature.

et al. (2019) who analyzed the effect of NTMs on firm-level exports in 42 developing countries, including 15 in Africa, albeit with key differences. The analysis in Fernandes et al. (2019) addresses a specific standard (i.e., pesticide regulations) in a specific sector (i.e., agriculture), while we focus on all technical measures and both the agriculture and manufacturing sectors.

Second, we contribute to understanding of the mechanisms by which these technical measures operate by looking at firm export decisions at extensive and intensive margins. As discussed earlier, these technical measures could affect both fixed and variable trade costs. Thus, the use of firm-level data enables us to examine whether firms adjust at the extensive margin (the probability of entering or exiting a destination market) or at the intensive margin (firm export value), in line with Melitz (2003); Chaney (2008). In this context, our analysis reveals that the African exporting firms included in our sample adapt at the intensive margin. This implies that these technical measures primarily act as variable trade costs, such as expenses accrued during the shift from low-quality to high-quality products, for these firms.

Third, we contribute to the literature that explores the heterogeneous effect of NTMS by exploring heterogeneities in the impact of technical measures across several dimensions. Recognising their potential heterogeneous effects on trade, we isolate the distinct effects of TBT and SPS on trade margins by including both in the same regression, similar to Fernandes et al. (2021). Also, by taking into account heterogeneity by firm size, our findings corroborate the prevailing observations in the empirical literature that small firms tend to be affected more by NTMs. Moreover, we show that firms with high product quality tend to benefit from the imposition of technical standards. Product quality is often viewed as a prerequisite for export success, integration into global trading systems and economic development (Kremer, 1993; Jaffee, 2003; Swinnen and Vandeplas, 2007; Amiti and Khandelwal, 2013). Standardization and certification could reduce transaction costs and act as catalysts for upgrading export sectors in developing countries leading to enhanced market access, and competitiveness. For instance, in Peru, Curzi et al. (2020) reports a quality upgrading effect in the agri-food sector induced by the most stringent standards. However, in the manufacturing sector, Doan and Zhang (2023) found a quality upgrading effect of TBTs for Chinese firms. In addition, Disdier et al. (2023) recently found a quality upgrading effect of quality standards for only highly productive French firms. They also found that NTMs boost the export sales of high product quality firms while diminishing those of lower product quality firms, which is in line with our findings. Yet we are unaware of any studies assessing the the role of initial quality in moderating the trade-reducing effect of NTMs in the African setting.[5]

The rest of the paper proceeds as follows. Section 2 provides a conceptual discussion of the trade effects of NTMs. Section 3 describes and provides stylized facts on firm-product level exports and country-product level non-tariff measures. Section 4 presents the empirical strategy used in the paper, while Section 5 presents and discusses the results. Section 6 concludes.

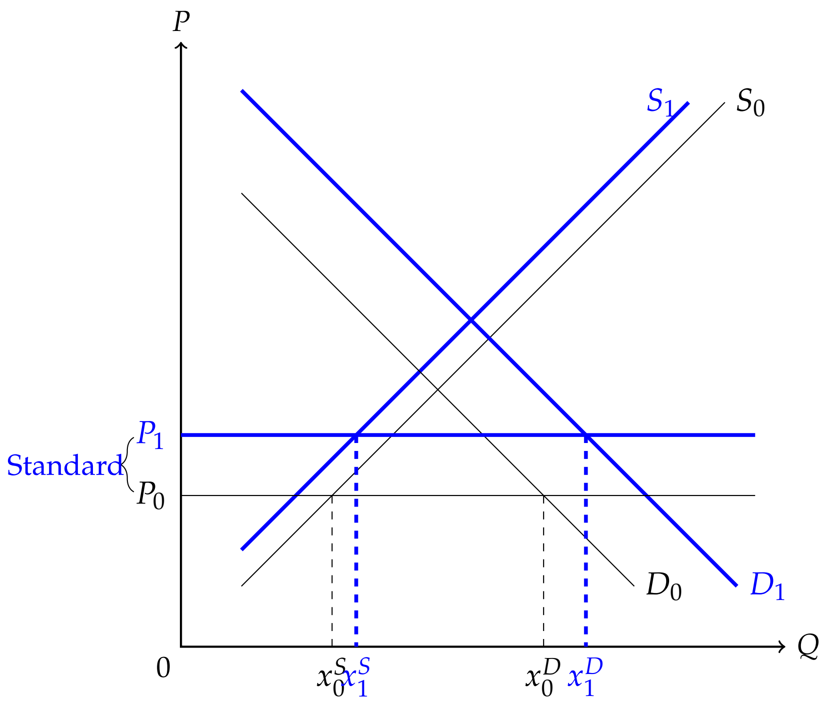
[5] Bastos et al. (2024) provide a descriptive analysis of the quality and quality-adjusted prices of Africa's imported digital goods, but they do not assess the impact of NTMs on quality.

2 Conceptual Framework

In this section, we provide a concise theoretical framework underlying the trade effects of standards. The aim is to highlight the important theoretical predictions that underpin our empirical analysis and help to make sense of our findings.

The introduction of quality standards imposes additional trade costs on both domestic and foreign firms. These extra costs include enforcement costs, process adaptation costs, and sourcing costs (Ing et al., 2016; De Melo and Shepherd, 2018). Enforcement costs encompass the efforts devoted by firms to show compliance with the standards, for example, the time devoted by staff to process paperwork, and inspections by officials from enforcement agencies. Process adaptation costs relate to capital adjustment costs incurred by firms to meet the required standards. Sourcing costs arise when firms are compelled to transition from low-quality intermediate inputs to high-quality ones to comply with the new standards.

Figure 1: Trade effects of standards in a small open economy



Source: adapted from Swinnen (2016)

How do these costs affect trade flows and market structure? For simplicity, let us assume the case of a small open economy that introduces a quality standard. Once the standard gets enforced, it affects the existing market equilibrium through a shift in both the demand and supply curves (Figure 1). The standard will cause a leftward shift of the domestic supply curve from $S_0 - S_1$. This shift reflects the increased cost of production for producers. However, because the standard addresses information asymmetries between producers and consumers, it will increase demand from $D_0 - D_1$. Parts of the increased domestic demand are met by imports (i.e., shift from $X_0^S - X_0^D$ to $X_1^S - X_1^D$) from countries where producers meet the standards enforced in the importing country.

However, how these costs affect trade and market structure also depends on whether they are fixed or variable. Enforcement and process adaption costs comprise the fixed cost components of standards. As evidenced in the literature on trade models with heterogeneous firms (Melitz, 2003; Helpman et al., 2004; Chaney, 2008, 2018), fixed costs play a crucial role in raising the export productivity threshold, thereby restricting export market access to only the most productive firms while pushing out the least productive ones from the export market, thus limiting them to selling only domestically. Consequently, these fixed costs associated with standards may reduce market entry, and encourage exit from the destination market where the standard is enforced. Sourcing costs are considered variable as they impact each unit produced. Theoretically, an increase in variable trade costs could diminish firm export values. However, they could also lead to the exit of marginal exporters, thereby making the effect on the intensive margin ambiguous without any assumption of the productivity distribution (Melitz, 2003). Nevertheless, these two effects cancel out and the intensive margin is unaffected under the assumption that firm-level productivity follows a Pareto distribution (Helpman et al., 2004; Chaney, 2018).[6]

In addition, the imposition of quality standards could also have political economy implications. For instance, Figure 1 captures an improvement in consumer welfare, as the gains from the outward shift of the demand curve are greater than the inward shift of the supply curve. If before the introduction of the standard at home there was equivalence with standards abroad (i.e., the free trade scenario) then imports could enter the home country at P_0. The introduction of standards raises the import competitive price to P_1.[7] The difference, $P_2 - P_1$, may reflect compliance cost pass-through to consumers in the importing country as higher prices, or quality upgrading and signalling. mechanisms.

But, do standards induce product quality upgrading? The a priori expectations here are less clear-cut. Recent extensions of the trade models with heterogeneous firms literature incorporate vertical quality differentiation across firms as key drivers of firms' export performance (Hallak, 2006; Crozet et al., 2012; Kugler and Verhoogen, 2011). Insights from these models show that successful exporters use higher-quality inputs and more skilled workers to produce higher-quality output that sells at higher prices. Consequently, firms with product quality below the prescribed standard may choose either to withdraw from the destination enforcing the standard or to enhance their product quality to sustain exports to that destination. However, the choice to upgrade depends on firm-specific attributes, given that adapting existing production technologies to meet the standards set by the importing country entails additional costs. For instance, more productive firms are more likely to upgrade their products as they can easily absorb the additional costs compared to less productive firms.

[6] Bernard et al. (2011) also showed that in the presence of multi-product exporters, the effect of variable trade cost on the intensive margin is ambiguous due to product composition effects.

[7] While the standards-trade effect may look similar to tariffs (e.g., raising domestic prices of imports as in Figure 1), direct comparisons between the two are not valid. Because a public standard is applied to all products marketed in the domestic country whether they are manufactured by foreign or by domestic firms, its effect (unlike that of a tariff) does not directly discriminate. Tariffs are by construction trade-reducing, but standards may also be market-creating measures. Here we see that the introduction of the standard increases domestic consumption ($X_0^D - X_1^D$), domestic production ($X_0^S - X_1^S$) and imports ($X_0^S - X_0^D$ to $X_1^S - X_1^D$). In any case, quality standards will always affect trade positively or negatively unless their effect on production exactly offsets their effects on consumption (Swinnen, 2016).

Using a trade model where firms are heterogeneous in both productivity and product quality and with the assumption of information asymmetry (where firms know their product quality but consumers only observe the average quality in the market), Disdier et al. (2023) demonstrated that enforcing a quality standard results in the exit of low-quality firms unable to meet the requirements, regardless of productivity. Conversely, high-productivity firms offering high-quality products can profitably reveal their quality, leading to a higher likelihood of exporting and larger export sales. Thus, the effect of NTMs on export margins also hinges on the initial quality of the firm's products.

Finally, standards may also affect trade through their effects on industry structure. For instance, within the trade models with heterogeneous firms framework, standards can decrease social welfare by reducing competition and product variety in the destination market imposing the standard (Abel-Koch, 2013). Due to the increased production costs, standards will induce market exit for firms that produce lower-quality products, and deter potential new exporters from exporting to the destination imposing the standard (trade cost effect). Conversely, standards serve as a signal of product quality, potentially bolstering consumer trust and thus increasing demand for these products. As demonstrated by Schmidt and Steingress (2022), the anticipated higher profits resulting from this heightened demand could incentivize market entry (quality effect). Consequently, the impact of quality standards on competition hinges on the relative magnitude of its trade cost and quality effects. If the trade cost effect outweighs the quality effect, the number of exporting firms dwindles, consequently diminishing competition. Surviving exporters may exploit the reduced competition in this new market environment and charge higher product prices. Yet, by excluding low-quality exports, standards may limit the scope for product quality differentiation and instead induce an increase in price competition (Ronnen, 1991).[8]

In summary, the conceptual discussions outlined above illustrate that the impact of standards on trade margins is theoretically ambiguous, and thus an empirical question. Furthermore, this impact is likely influenced by firm-specific characteristics such as productivity and initial product quality. Imposing standards may also induce product upgrading by firms to maintain exports to the affected destination, an effect which is also likely to be contingent upon the characteristics of the firm.

3 Data

3.1 *Non-tariff measures*

We create a bilateral NTM variable using information from the Vienna Institute for International Economic Studies NTM database (Ghodsi et al., 2017).[9] The majority of the measures we observe are imposed by destinations in a non-discriminatory manner to all WTO member

[8]This will occur if mandatory compliance with the public standard leads firms that before the introduction of the standard were producing "low-quality" to improve their quality. In this case, the difference in quality between surviving firms reduces after the introduction of the standard. This will cause an increase in price competition and, as a consequence, a reduction in quality-adjusted prices.

[9]The data is publicly available at https://wiiw.ac.at/wiiw-ntm-data-ds-2.html

countries, with only a few being applied bilaterally.[10] The database is based on the WTO notifications available from the Integrated Trade Intelligence Portal (I-TIP) for more than 100 importers and over 5,000 products for the period 1995-2019, complemented with data from Bown (2016).[11] This dataset simplifies econometric analysis because it has been enriched by imputing missing product codes at HS 6-digit level. The final dataset provides information on (i) the concerned country and the country implementing the measure, (ii) the year the measure was introduced, (iii) the affected HS 6-digit product, (iv) the nature of the measure (e.g., SPS, TBT, quantitative restrictions[12]), and (v) where applicable, the actual date the measure was removed. Using this information, we calculate the count of SPS and TBT measures imposed by a destination country to exports of HS6-digit products from an origin country. This count proxies regulatory intensity with regulatory burden increasing with increasing count of NTMs.

3.1.1 *Stylized facts on non-tariff measures*

Over time, the use of NTMs to regulate trade flows has increased. The number of countries imposing an NTM, whether SPS and/or TBT measures, either unilaterally or bilaterally on exports from Burkina Faso, Malawi, and Senegal has been on a steady increase since 2000 (Figure 2a). The number of unique HS6-digit products that attract an NTM has also been rising since 2003. We observe a similar pattern for both SPS and TBT measures and in both the agriculture and manufacturing sectors (see Figure A2). This contrasts with the use of tariffs which have been on a downward trend over a similar time frame (see Figure 4).

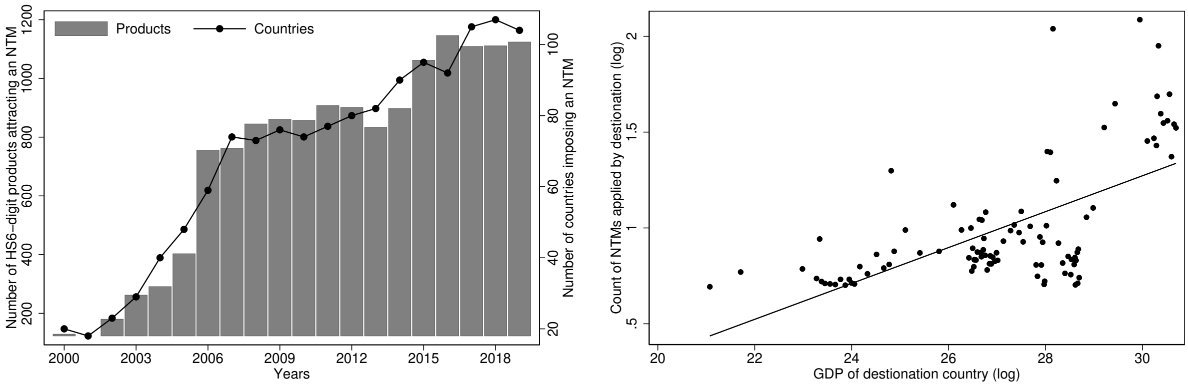
When it comes to the use of NTMs to regulate trade, there is a clear divide between developed and developing countries. Often, the higher the income level of a country, the lower the level of tariffs and the higher the likelihood of making extensive use of standard-like NTMs (World Bank, 2020; Garcés and Vogt, 2024). We observe a similar pattern in our dataset: developed countries—measured in terms of their gross domestic products—are more likely to use standard-like NTMs as market access tools (see Figure 2b).

[10] Using NTM data from multiple sources, Garcés and Vogt (2024) review the intensity, prevalence and structure of NTMs globally and confirm that the majority of technical measures are formally applied in a non-discriminatory fashion across trading partners.

[11] This dataset contains information on antidumping, countervailing, and safeguard measures for about 30 countries. The data is available at https://www.worldbank.org/en/data/interactive/2021/03/02/temporary-trade-barriers-database

[12] We limit our focus to standards and technical regulations, that is, SPS and TBT measures. At this stage, we only lose 1% of the observations when we do this. TBT measures make up 66% of the sample observations and SPS measures make up 32.74%. With the 1% we exclude made up of non-technical measures such as pre-shipment controls, quantity controls, and price controls.

Figure 2: The proliferation of NTMs over time and development level of destinations



(a) Proliferation of NTMs

(b) The use of NTMs by income status

3.2 *Firm-level export data*

Our source of firm-level customs transaction data for the three selected African countries is the Exporter Dynamics Database, described in Fernandes et al. (2016). The data is collected by the Trade and Integration Unit in the Development Research Group at the World Bank from the customs agencies and statistical institutes of the respective countries. For each transaction, the firm-level customs data contains unique information on the exporting firm, the country of origin, the export destination, the product classification at the HS6-digit level, the year of the transaction, and the Free on Board (FOB) value and quantity of export. As such our unit of analysis is at the firm-product-destination-year level.[13]

We make use of firm-level customs transactions for three selected African countries due to data availability. These include Burkina Faso (2005-2012), Malawi (2006-2019), and Senegal (2000-2019). To merge the NTM panel data with the firm-level trade data at the HS6 product level, we convert the HS6 product codes in both the firm-level trade data and the NTMs data into a consolidated version, following the procedure outlined in Fernandes et al. (2016).

3.2.1 *Stylized facts on firm-level exports*

We observe a total of 16,021 unique firms throughout the sample used in the study. Of these, 1,579 firms are located in Burkina Faso, 8,015 firms are located in Malawi, and 6,428 firms are located in Senegal (Table 1). About 70% of the firms are active exporters in the manufacturing sector with the remaining 30% exporting agricultural products. The number of firms we observe increased a lot over time from 320 firms in 2000 to 2,407 firms in 2019. The same is true for the number of products exported by the firms and the number of destinations that they serve. We also observe that the number of high-income destinations has risen over time, increasing from 23 in 2000 to 63 in 2019. However, most firms only serve a few destinations or export a few products (see Figure A3). The average firm only serves three destinations and exports 29 products, with differences across origin countries and sectors. The average

[13] We followed the procedure outlined in Fernandes et al. (2016) to clean the firm level data.

destination per firm varies from a low of two destinations in Malawi to a high of four destinations in Senegal. The average number of exported products also ranges from 6 in Burkina Faso to 16 in both Malawi and Senegal. On average, a higher number of unique products are exported per firm in the agriculture sector relative to the manufacturing sector. Whereas the number of destinations served per firm remained rather stable over time, the number of products exported per firm increased over time.

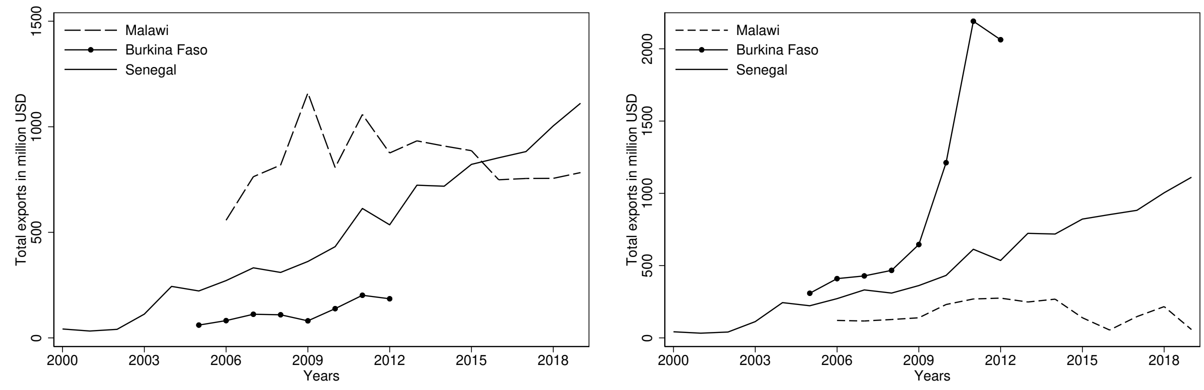
Table 1: Firm-level characteristics across countries, economic sectors, and years

	N	Firms	HS6	Dest.	HI Dest.	Value	Quantity	Per firm	
							Dest.	HS6	
Total sample	233,922	16,021	3,632	233	79	214,812	340,802	3	29
Countries									
Burkina Faso	17,091	1,579	1,664	156	54	508,819	299,290	3	6
Malawi	62,666	8,015	2,598	193	69	226,952	17,7068	2	16
Senegal	154,165	6,428	3,300	225	79	177,283	411,966	4	16
Product sectors									
Agriculture	66,665	5,171	549	220	75	336,710	282,125	3	34
Manufacturing	167,257	12,729	3,083	223	76	166,226	364190	2	28
Years									
2000	2,206	320	737	62	23	82,482	589,905	3	2
2005	7,974	1,041	1,437	144	49	138,385	336,039	3	4
2010	13,943	2,432	1,894	170	61	263,830	431,296	2	5
2015	17,881	2,621	1,982	177	65	173,551	292,172	3	6
2019	16,242	2,407	2,007	189	63	244,241	349,700	3	5

Notes: N is the total number of observations. HS6 denotes the number of products defined at the HS6 digit level. Dest. denotes the number of unique destinations while HI Dest. denotes the number of unique high-income destinations. For brevity, the data across years are only reported for every fourth year.

We also depict trends in exports over time, aggregated across the origin countries and sectors (Figure 3). Overall, we observe growth in export values over time in Senegal and Burkina Faso, whereas Malawi displays fluctuations without any discernible change over time. What becomes obvious is that specialization patterns in production are different across the three countries. Malawi exports mostly products in the agriculture sector. Burkina Faso exports mostly products from the manufacturing sector. Senegal, on the other hand, while exporting mainly products in the agriculture sector also shows a lot of exports in manufacturing.

Figure 3: Trend in total export values over time across countries by sector



(a) Agriculture

(b) Manufacturing

3.2.2 *Margins of export adjustment*

Following Fernandes et al. (2016), we consider both the extensive and intensive margins of exports to capture the export decision of firms. This is relevant given that various margins of trade adjustment may respond differently to trade costs. To define variables encompassing the firm's extensive margin, we adhere to existing literature (Fernandes et al., 2016), and expand our initial dataset, which solely contains data on positive trade flows, by inserting zero export values for the years when exports within the firm-product-destination grouping do not take place. We then consider three alternate measures that capture the extensive margin of trade: (i) an export participation dummy variable which takes the value of 1 if firm i in country c exports a positive value of product p to destination d in year t, and zero otherwise, (ii) a firm entry dummy variable which takes the value of 1 if firm i in country c exports product p to destination d in year t but did not do so in year $t-1$, and zero otherwise[14], and (iii) a firm exit dummy variable which takes the value of 1 if firm i in the country c did not export product p to destination d in year t but did so in year $t-1$, and zero otherwise.[15] Finally, we define the intensive margin as the FOB export value in USD of firm i in country c of product p to destination d in year t.

3.3 *Auxiliary data: Bilateral tariffs*

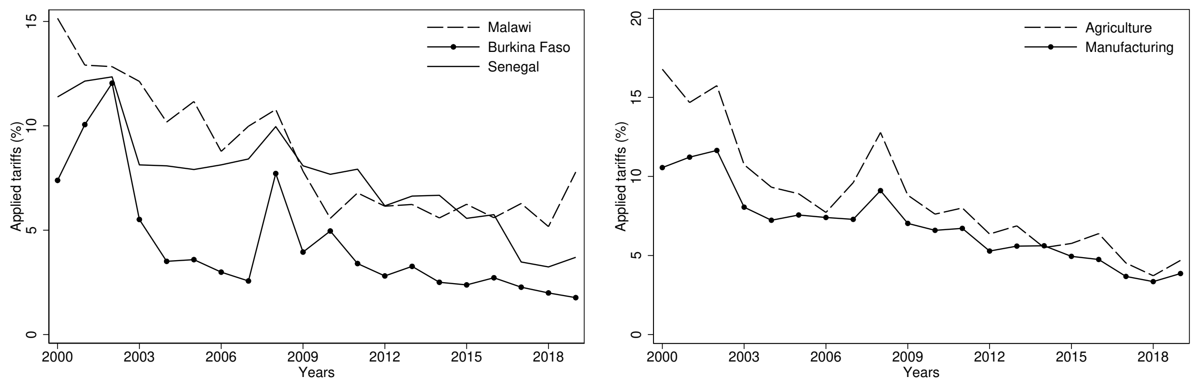
While NTMs are proliferating in scope and stringency, tariffs remain the classical market access tool. We access applied bilateral tariff data from the World Integrated Trade Solution (WITS). In cases where applied tariffs are preferential, we use the latter. Where both applied or preferential rates are missing we use the most-favored-nation or the bound rates.

[14]We omit firms that have exported to a product-destination market every year from the entry probability analysis. Also, we exclude the initial year of the sample from this analysis because we cannot ascertain whether this is the first time the firms are entering the market or not.

[15]We do not include firms that exported solely to a product-destination market in the last year of the sample in our market exit probability analysis.

Overall, we observe a decrease in applied tariffs over the study period across all countries (Figure 4a). We observe a similar pattern across sectors with a little more reduction in the manufacturing sector compared to the agriculture sector where protection remains high globally (Figure 4b). The trends we see for tariffs and NTMs are quite different: tariffs have been steadily decreasing over time, while NTMs are becoming more widespread. Whereas these patterns reflect substitution between NTMs and tariffs as market access tools, empirical evidence confirms the existence of both complementarity and substitution effects (Niu et al., 2020).

Figure 4: Trend in applied tariffs across countries and sectors over time



(a) Across origin countries (b) Across sectors

4 Empirical Strategy

4.1 *Model specification*

To examine the effects of NTMs imposed by destination countries on firm-level exports, we estimate the following model:

$$y_{icpdt} = \beta_0 + \beta_1 NTM_{pcdt} + \beta_2 \ln Tariff_{cp_{hs4}dt} + \omega_{icp} + \lambda_{ipt} + \gamma_{dt} + \epsilon_{icpdt} \tag{4.1}$$

where y_{icpdt} is the dependent variable for firm i, in origin country c, exporting HS6-digit product p, to destination d, in year t. y_{icpdt} is defined to include firm exit dummy, firm entry dummy and log of firm export value, as defined in subsection 3.2. The variable NTM_{pdt} is the count of the number NTM imposed by the importing country d, on product p, in year t (as discussed in subsection 3.1). The variable $Tariff_{cp_{hs4}dt}$ is the specific bilateral tariff imposed by the destination country d at the HS4-digit product level, on imports from the exporting country c. To reduce the number of missing values, we access the tariff data at the HS4 digit level.

Equation 4.1 also includes a host of fixed effects. ω_{ipd} is the firm-origin-HS6 product fixed effect, which accounts for all time-invariant firm unobservable characteristics. λ_{ipt} is the firm-HS6 product-year fixed effect, which controls for all firm-level time-varying characteristics, including firm-level productivity. This fixed effect also accounts for all the origin country-level time-varying characteristics such as the gross domestic product. γ_{dt} is the destination country year fixed effect, which accounts for all the destination country level time-varying characteristics. Finally, ϵ_{icpdt} is the error term.

We estimate Equation 4.1 using OLS, which implies that we use the linear probability model when the dependent variable takes the form of a dummy variable. This is because it is not feasible to estimate non-linear models such as probit models due to the inclusion of fixed effects. For export values we employ an alternative estimator, the Poisson pseudo-maximum likelihood (PPML) estimator (Santos Silva and Tenreyro, 2006) to account for zero trade observations and to address heteroskedasticity, and report the results in Appendix A2.[16] Summary statistics on all variables included in all variants of Equation 4.1 are presented in Table A1.

4.2 *Identification strategy*

Our coefficient of interest is β_1. This coefficient is identified based on the changes in market entry, market exit, and export values within the same firm-origin-HS6-digit product p combination, in response to the variation in the number of NTMs imposed by the importing country on HS6-digit product p from origin c over time.

We acknowledge that there are several variables influencing trade margins that haven't been incorporated into our model because they are not observable, thus raising concerns about omitted variables. Nevertheless, the inclusion of the rich set of fixed effects in our model accounts for all unobservable time-invariant factors, as well as firm-level time-varying traits and time-varying characteristics of both origin and destination countries that may affect trade margins. There's also a potential issue of reverse causality if an importing country imposes an NTM on a product due to increased imports from a specific country. While this may be a valid concern, NTMs are also not specific to individual firms. Hence conducting the analysis at the firm level using NTMs applied in an MFN manner helps mitigate reverse causality concerns. It's also worth noting that most of the existing literature at the firm level adopts a similar approach (see for example Fontagné et al., 2015; Fernandes et al., 2019).

5 Results

5.1 Non-tariff measures and firm-product level exports

Table 2 presents the estimation results of the impact of NTMs on the extensive and intensive margins of trade. Columns 1 to 3 show the impact of NTMs on the probability of export market entry for all sectors, the agriculture sector, and the manufacturing sector respectively. Similarly, columns 4 to 6 show the impact on the market exit rate, while columns 7 to 9 report the impact on the intensive margin.

[16] We acknowledge that the PPML estimator has become the workhorse estimator in the international trade literature. We report the OLS estimates in the main text only to ensure consistency in the estimator across the different export margins. Also, as the results from our PPML estimates in the Appendix show, there are little differences across the results from the OLS and PPML estimator.

We do not find any impact of the imposition of NTMs on the extensive margin, whether across all sectors or specifically within the agriculture and manufacturing sectors. Theoretically, the decision to enter or exit a product-destination market depends on the trade cost and quality effect of the imposition of standards. The anticipated higher profits resulting from a heightened demand due to the quality standards could incentivize firms to enter or remain in the market (Schmidt and Steingress, 2022) while the increased fixed costs could induce market exit for firms that produce lower-quality products, and deter potential new exporters from exporting to the destination (Melitz, 2003). Our empirical findings, therefore, suggest that these two forces nullify each other.

Table 2: The effect of non-tariff measures on firm-level margins of trade

	Extensive margins						Intensive margin		
Outcome:	Export Entry Dummy			Export Exit Dummy			Export Value (logs)		
	All	Agric.	Manuf.	All	Agric.	Manuf.	All	Agric.	Manuf.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log NTM_{pcdt}	0.000	0.001	-0.000	-0.000	0.000	-0.001	-0.070^{*}	-0.166^{*}	-0.125^{**}
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.041)	(0.085)	(0.063)
log $Tariff_{pcdt}$	-0.000	-0.000	-0.000^{**}	-0.000	-0.000	-0.000^{*}	0.012	0.035	-0.019
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.016)	(0.033)	(0.015)
Observations	1,319,162	403,212	915,479	1,392,332	425,985	965,843	101,379	39,502	61,265
Adjusted R^2	0.217	0.202	0.227	0.210	0.191	0.220	0.631	0.542	0.646

Notes: "All" denotes all sectors, "Agric." denotes the agriculture and food sectors, while "Manuf." indicates the Manufacturing sector. Robust standard errors clustered at the origin-destination-product level are in parentheses. ***, ** and * denote significance at 1%, 5%, and 10%. All models include controls for firm-origin-product, firm-product-year and destination-year fixed effects, which are excluded from the table for brevity.

On the other hand, we find a negative and statistically significant effect of NTMs on the intensive margin. For all sectors, a 1% increase in the number of NTMs imposed on an HS6 product decreases the value of firm-level exports by 0.07% (column 7). This negative effect is particularly pronounced in the agriculture sector compared to the manufacturing sector, with elasticities of approximately -0.16% and -0.13%, respectively (columns 8 and 9). This finding confirms that of Fontagné et al. (2015) and Curzi et al. (2020) who found a negative impact of standards on the intensive margin. As previously discussed in section 2, the effect of NTMs on the intensive margin remains theoretically unclear and thus an empirical question. A rise in trade costs could potentially diminish the value of firm-level exports, yet it might also prompt marginal exporters to withdraw from the market. Therefore, the negative effect on the intensive margin could stem from the absence of any observable impact of NTMs on the probability of exit. This suggests that NTMs serve as a variable trade cost in our context and affect the intensive margin negatively. 0ur finding that the negative effect is more pronounced in the agriculture sector than in the manufacturing sector is consistent with the existing literature (e.g., Li and Beghin, 2012; Bacchetta and Beverelli, 2012), suggesting that adaptation costs are relatively lower in the manufacturing sector compared to the agriculture sector.

In all cases, we observe that ad-valorem tariffs have no statistically significant effects on the different margins of export adjustment. Globally tariffs have been on a decline (see Figure 4), with these tariff reductions even more pronounced for African countries who enjoy unilateral and bilateral tariff cuts within the scopes of trade preferences granted by developed countries. What our results show, therefore, is that non-tariff measures in destination markets and not tariffs are the more relevant threat to Africa's integration into the global trading system.

5.2 Heterogeneity Analysis

In this section, we assess how heterogeneous our findings are along several dimensions. Given that we observe in our baseline models, that standards and technical regulations have no effects on the extensive margin of trade adjustment, we focus the presentation of our heterogeneous analyses on the intensive margin.

5.2.1 NTM Class: SPS and TBT measures

Given the disproportionate use of SPS and TBT measures in agriculture and manufacturing, we assess whether and to what extent their effects on firm-level exports differ. Empirically, we decompose the variable NTM_{pcdt} into the number of SPS measures (SPS_{pcdt}) and TBT measures (TBT_{pcdt}) imposed on product p exports from country c to country d in year t. We present the results in the first three columns of Table 3. At the intensive margins, we find that both SPS and TBT measures reduce export values in the agriculture and manufacturing sectors, respectively.

5.2.2 Intermediate vs Final Goods

Trade costs may affect final and intermediate goods differently (e.g., Antras and Chor, 2018; Franco-Bedoya and Frohm, 2020), as these products have varying levels of protection, substitutability, and degree of health and safety risk to consumers. Final goods are intended for consumption, whereas intermediate inputs are meant to be incorporated into subsequent production processes. Indeed, Franssen and Solleder (2016) find that final goods are regulated heavier by NTMs compared to intermediate goods.

We thus examine whether technical measures affect trade differently based on the position of the good along the value chain; that is whether the goods are intermediate goods or for immediate consumption (i.e., final goods), following the Broad Economic Classification (BEC). To assess this heterogeneity, we define a dummy variable (NC_p) equal to one if the product is an intermediate, and zero otherwise. We then interact this dummy variable with log NTM_{pcdt}. Columns 4 to 6 of Table 3 shows the results of this analysis. We observe that the estimated coefficient on this interaction term (log $NTM_{pcdt} \times NC_p$) is positive and statistically significant in all three cases. This suggests that non-consumables are less negatively affected by NTMs than consumables. Specifically, the trade effect is positive for non-consumable goods, when we pool all the sectors together. Within the agriculture sector, the negative trade effect is confined to consumable goods, whereas within the manufacturing sector, the negative impact on non-consumable goods is less pronounced. Hence, for products that pose direct risks to health and safety, the effect of technical measures is more pronounced and the effect varies by sector. This could be because, in many instances, technical measures are *prima facie* introduced to correct market imperfections, including alleviating information asymmetry and mitigating risks associated with consuming certain goods.

Table 3: The effect of non-tariff measures on firm-level intensive margin of trade: Heterogeneity by Class of NTM, Product Position along the Value Chain and Firm size .

Outcome:	Export Value (logs)								
Heterogeneity:	Class of NTM			Product's position along VC			Firm Size		
	All	Agric.	Manuf.	All	Agric.	Manuf.	All	Agric.	Manuf.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log NTM_{pcdt}				−0.179***	−0.268***	−0.254***	−0.186***	−0.222**	−0.369***
				(0.056)	(0.093)	(0.095)	(0.065)	(0.113)	(0.096)
log SPS_{pcdt}	−0.090*	−0.244**	−0.042						
	(0.048)	(0.100)	(0.132)						
log TBT_{pcdt}	−0.031	0.013	−0.155**						
	(0.062)	(0.146)	(0.066)						
log $NTM_{pcdt} \times NC_p$				0.224***	0.268***	0.155*			
				(0.062)	(0.072)	(0.088)			
log $NTM_{pcdt} \times LF_i$							0.135**	0.054	0.312***
							(0.069)	(0.092)	(0.100)
log $NTM_{pcdt} \times MF_i$							0.109*	0.061	0.202**
							(0.060)	(0.083)	(0.086)
log $Tariff_{pcdt}$	0.012	0.037	−0.019	0.010	0.028	−0.019	0.012	0.035	−0.019
	(0.016)	(0.033)	(0.015)	(0.016)	(0.033)	(0.015)	(0.016)	(0.033)	(0.015)
Observations	101,379	39,502	61,265	101,379	39,502	61,265	101,379	39,502	61,265
Adjusted R^2	0.632	0.542	0.646	0.631	0.542	0.646	0.632	0.542	0.646

Notes: "All" denotes all sectors, "Agric." denotes the agriculture and food sectors, while "Manuf." indicates the manufacturing sector. NC_p is equal to one if the product is an intermediate one, and zero otherwise. LF_i and MF_i are dummy variables indicating whether a firm is large (LF_i) or medium (MF_i) respectively. Robust standard errors clustered at the origin-destination-product level are in parentheses. ***, ** and * denote significance at 1%, 5%, and 10%. All models include controls for firm-origin-product, firm-product-year and destination-year fixed effects, which are excluded from the table for brevity.

5.2.3 Firm Size

We now examine whether the trade effect of NTMs varies with firm size. Given both internal (e.g., scale, productivity, experience, technology) and external (e.g., border and behind-the-border measures) barriers to international trade, there are likely to be scale effects. In a Melitz (2003)-style framework with heterogeneous firms and fixed market-entry costs, the effect of trade policies on export performance is decreasing in firm-level productivity, which in many cases is positively associated with firm size. If increases in trade costs raise the productivity threshold required for trading, then in a standard heterogeneous firm model of trade with constant elasticity of substitution (CES) preferences (Melitz, 2003; Chaney, 2008), a large number of, mostly small, firms will stop trading. Even if we allow for firm-specific entry costs, Arkolakis (2010) predicts that when trade costs increase, trade shares are reallocated away from small firms because sales' elasticity for variable trade costs is decreasing in firm size. The resulting tougher competitive environment in the domestic market reinforces the link between productivity and size. This will imply a heterogeneous effect on the intensive margin of individual exporters if we assume that large firms are better at bearing the costs or face lower elasticity of substitution (Spearot, 2013). Hence, we expect the trade costs induced by country-specific variation in NTMs to be more pronounced for smaller firms. However, because larger exporting firms are likely to sell to multiple destinations, at the same time they are also likely to be exposed to more risk from country-varying NTMs.

We categorize firm size by dividing them into three (terciles) based on the firm's export shares in its initial year of the sample. Firms with exports in the 3rd tercile are classified as large, those whose exports fall within the 2nd tercile are considered medium-sized, while the rest (1st tercile) are considered small-sized firms. We then interact our main variable of interest with two different dummy variables indicating whether a firm is large (LF_i) or medium (MF_i). The reference group is thus the small-sized firms. The results presented in the last three columns of Table 3 are in line with the predictions of the heterogeneous firm models, given that the coefficient on the interaction term is positive. When considering all sectors together, we observe that the trade-reducing effect of NTMs is decreasing in firm size with the observed trade effects being lower for large and medium-sized firms compared to small firms (column 7). However, within the agriculture sector, the size of the firm does not moderate the trade-reducing impact of NTMs, as indicated by the lack of statistical significance in the interaction terms (column 8). Conversely, we find that NTMs have a relatively milder impact on trade for large and medium-sized firms compared to small firms in the manufacturing sector (column 9).

5.2.4 Characteristics of destination and origin

As we observe in Panel B of Figure 2, when it comes to the use of NTMs to regulate trade, there is a clear developed-developing country divide, with the number of NTMs imposed by the destination increasing with income level of the destination country. According to World Bank (2020), the higher the income level of a country, the lower the level of tariffs and the higher the likelihood of making extensive use of standard-like NTMs. This suggests that the impact of NTMs on the intensive margin could differ by the income status of the destination country. To test this conjecture, we define a dummy variable (NHI_d) that takes the value of one if the destination is not classified as a high-income country according to the World Bank income classification, and zero otherwise. We then interact this variable with our measure of NTM. The results are shown in columns 1 to 3 of Table 4. The result suggests that the trade-reducing effect of NTMs does not depend on the income status of the destination country. Thus, the effect of NTMs on the intensive margin of firm level trade holds irrespective of the income level of the destination country.

Table 4: The effect of non-tariff measures on firm-level intensive margin of trade: Heterogeneity by Income Status of Destination Country, Destination and Origin.

Outcome:	Export Value (logs)								
Heterogeneity:	Income Status			Africa vs Rest of the World			Origin		
	All	Agric.	Manuf.	All	Agric.	Manuf.	All	Agric.	Manuf.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log NTM_{pcdt}	-0.121^{**}	-0.229^{**}	-0.216^{**}	-0.093^{*}	-0.197^{*}	-0.174^{**}	-0.107^{**}	-0.236^{***}	-0.113^{*}
	(0.053)	(0.111)	(0.089)	(0.050)	(0.101)	(0.080)	(0.043)	(0.090)	(0.065)
	(0.016)	(0.033)	(0.015)	(0.016)	(0.033)	(0.015)	(0.016)	(0.033)	(0.015)
log $NTM_{pcdt} \times NHI_d$	0.120	0.166	0.176						
	(0.076)	(0.155)	(0.117)						
log $NTM_{pcdt} \times AFR_d$				0.089	0.141	0.123			
				(0.098)	(0.176)	(0.121)			
log $NTM_{pcdt} \times BFA_c$							0.041	0.200	-0.101
							(0.087)	(0.146)	(0.112)
log $NTM_{pcdt} \times MWI_c$							0.161	0.221^{*}	-0.041
							(0.101)	(0.124)	(0.091)
log $Tariff_{pcdt}$	0.012	0.035	-0.019	0.012	0.036	-0.019	0.012	0.036	-0.019
Observations	101,379	39,502	61,265	101,379	39,502	61,265	101,379	39,502	61,265
Adjusted R^2	0.632	0.542	0.646	0.631	0.542	0.646	0.632	0.542	0.646

Notes: "All" denotes all sectors, "Agric." denotes the agriculture and food sectors, while "Manuf." indicates the Manufacturing sector. Robust standard errors clustered at the origin-destination-product level are in parentheses. ***, ** and * denote significance at 1%, 5%, and 10%. All models include controls for firm-origin-product, firm-product-year and destination-year fixed effects, which are excluded from the table for brevity.

Intra-African borders remain 'thick', with many barriers including NTMs inhibiting regional trade (Brenton et al., 2014; Cadot and Gourdon, 2014). For instance, Sanjuán López et al. (2021) found that both technical and non-technical NTMs reduce intra-Africa trade. We thus assess whether the trade-reducing effect of NTMs on the intensive margin is less or more pronounced for intra-Africa exports compared to exports to destinations outside the continent. To do this, we interact an indicator variable for Africa destinations (AFR_d) with our main variable of interest. The results are reported in columns 4 to 6 of Table 4. The coefficient of the interaction term (log $NTM_{pcdt} \times AFR_d$) is positive but statistically insignificant in all three cases, implying that the trade-reducing impact of NTMs doesn't vary significantly between intra-Africa trade and Africa's trade with other regions of the world.

As is evident in Table 1 and Figure A2, the specialization patterns and the trends in exports differ markedly across the different African countries we consider. Exports from Burkina Faso are concentrated in the manufacturing sector, exports from Malawi are concentrated in the agriculture sector, and Senegal's exports display a mix of both. Since the use of NTMs to regulate trade is different across sectors, this section tests whether the NTM-trade effect varies based on origins given the observed product specialization patterns. We define two dummy variables and interact them with our variable of interest. The first dummy variable indicates whether the origin country is Burkina Faso (BFA_c), and the second indicates whether the origin country is Malawi (MWA_c). The reference country is thus Senegal. We find that trade reducing effect of NTMs does not differ significantly between the two countries and Senegal, with the only exception being the agriculture sector, where we find a marginally less pronounced negative effect in Malawi compared to Senegal (see columns 7 to 9 of Table 4).

5.3 Quantity, Price and Quality Effects

In this section, we decompose the negative effects of NTMs on the intensive margin of firm level trade into product prices and product quantities. On average, we find no effects of NTMs on the import quantities and prices. Across sectors, however, we find different effects. In agriculture, NTMs reduce prices received by exporting firms while exported quantities remain unchanged. If prices proxy quality (e.g., Fernandes et al., 2019), we can interpret this to mean that African countries receive lower prices for exporting lower quality products. In the manufacturing sector, NTMs reduce export volumes but do not affect export prices.

Table 5: The effect of NTMS on quantity and prices

	All sectors		Agriculture		Manufacturing	
Outcome:	Quantity	Unit Values	Quantity	Unit Values	Quantity	Unit Values
	(1)	(2)	(3)	(4)	(5)	(6)
log NTM_{pcdt}	−0.063	−0.007	−0.110	−0.057**	−0.129**	0.004
	(0.041)	(0.014)	(0.082)	(0.025)	(0.063)	(0.032)
log $Tariff_{pcdt}$	0.011	0.001	0.039	−0.003	−0.021	0.003
	(0.016)	(0.004)	(0.031)	(0.008)	(0.015)	(0.006)
Observations	101,379	101,379	39,502	39,502	61,265	61,265
Adjusted R^2	0.762	0.823	0.632	0.803	0.786	0.824

Notes:

It is also possible that NTMs induce firm-level product quality upgrading. There is some evidence to that effect even in the agriculture sector (e.g., Curzi et al., 2020). Thus, it is possible that interpreting our price effects in Table 5 as quality upgrading may be misleading if in our setting unit values do not proxy quality perfectly, but instead reflect differences in efficiency, market power or foreign exchange differences. As a result, we also test the effects of NTMs on product quality upgrading for African exporting firms. To confirm the existence of such an effect, we need to introduce a measure of product quality into our analysis. As such, we follow the set up in Khandelwal et al. (2013) to recover estimated product quality directly from observed trade data. For brevity, we relegate the description of the quality estimation procedure to the Appendix A1. We plot a graph of estimated quality and prices in Figure A1 and find that prices and quality are positively correlated with the correlation being stronger in the manufacturing sector compared to agriculture. Regressing quality and quality-adjusted prices on NTMs, we find no evidence that NTMs induce a quality upgrading effect for firm-product level exports (Table 6[17]), giving further credence to our findings in Table 5. If we adjust prices for quality differences, export prices in the agriculture sector remain lower in the presence of NTMs while export prices in the manufacturing sector are higher in the presence of NTMs.

This notwithstanding, the effects of NTMs may also be moderated by product quality Disdier et al. (2023). For instance, their trade effects may be more pronounced in sectors where product quality is high, for example, high-value products in the manufacturing sector, but

[17] Since prices are noisy and our quality estimates will be sensitive to this noise, we drop unit values above the 99th percentile and below the 1st percentile of the unit value distribution.

Table 6: The effect of NTMS on prices, quality and quality adjusted prices

	All sectors			Agriculture			Manufacturing		
Outcome:	UV	Qual	QAP	UV	Qual	QAP	UV	Qual	QAP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log NTM_{pcdt}	−0.020	−0.007	−0.013	−0.076***	0.010	−0.086***	0.044	−0.054	0.098*
	(0.017)	(0.017)	(0.021)	(0.027)	(0.022)	(0.030)	(0.043)	(0.049)	(0.051)
log $Tariff_{pcdt}$	0.003	−0.005	0.007	−0.010	0.005	−0.016	0.008	−0.010	0.018*
	(0.006)	(0.006)	(0.007)	(0.009)	(0.008)	(0.011)	(0.007)	(0.009)	(0.009)
Observations	69,701	69,701	69,701	31,555	31,555	31,555	38,013	38,013	38,013
Adjusted R^2	0.823	0.312	0.825	0.834	0.250	0.814	0.816	0.336	0.838

Notes: The dependent variable is the product p imports of firm f from origin o in year t. p values are in parentheses. ***, ** and * denote significance at 1%, 5%, and 10%. Intercepts included but not reported. Standard errors are clustered at the firm-product-year level.

also sector such as fish and fish products, and fruits and vegetables. We define a firm's initial product quality as the estimated quality of the product that the firm exported to a particular destination in the first year of exporting to that destination within the sample period. We then use the median of the quality distribution as a breakpoint to define two groups of high- and low-quality products. We consider products $\leq$ to the median quality value as low quality. These products display very little product differentiation. Products $>$ the median quality value displays a lot of vertical product differentiation and fall into the high-quality product category. We then introduce an interaction term of high initial product quality (PQ_{ipcd}) and the NTM variable into our baseline specification. The findings are reported in Table 7. We find that initial product quality moderates the trade-reducing effects of NTMs. Specifically, our findings reveal that the trade-reducing effect of NTMs at the intensive margin is reversed for firms with higher initial product quality in the manufacturing sector, and is less pronounced for firms with relatively high initial product quality in the agriculture sector. These findings are in line with Disdier et al. (2023), who found that NTMs boost the export sales of high product quality firms while diminishing those of lower product quality firms.

5.4 Robustness checks

In this section, we subject our main findings to a series of sensitivity analyses to check the robustness of our main findings. We begin by estimating the effects of NTMs on the intensive margin of trade using the PPML estimator (Santos Silva and Tenreyro, 2006). The estimator's log-linear objective function allows us to specify the gravity equation in its multiplicative form without log-transforming the dependent variable and is consistent under heteroskedasticity (see Appendix A2 for a discussion of the properties of the estimator and the model specification). The results presented in Table A2 support our main findings. The effects are, however, estimated with a higher level of precision at the 1% significant level and the magnitudes of the estimated effects are larger than those from our baseline model with the OLS.

In the preceding sections, we make use of the logarithm of the number of NTMs imposed on a product p, from origin c if we consider just the presence of NTMs? To answer this question, we define a dummy variable (NTM_{pcdt}) that takes the value 1 if the count of NTMs

Table 7: The effect of non-tariff measures on firm-level export margins by initial product quality

	Extensive margins						Intensive margin		
Outcome:	Export Entry Dummy			Export Exit Dummy			Export Value (logs)		
	All	Agric.	Manuf.	All	Agric.	Manuf.	All	Agric.	Manuf.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log NTM_{pcdt}	-0.003^{***}	-0.003	-0.003	-0.003^{***}	-0.001	-0.003	-0.730^{***}	-0.817^{***}	-0.711^{***}
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.055)	(0.102)	(0.102)
log $NTM_{pcdt} \times PQ_{ipcd}$	0.006^{***}	0.006^{***}	0.009^{***}	0.004^{***}	0.003^{***}	0.007^{***}	0.801^{***}	0.805^{***}	0.788^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.038)	(0.041)	(0.076)
log $Tariff_{pcdt}$	-0.000	0.000	-0.001	-0.001^{**}	0.000	-0.001^{***}	0.031	0.062	-0.010
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.020)	(0.039)	(0.019)
Observations	813,227	287,893	525,158	859,069	304,406	554,477	79,742	34,514	44,971
Adjusted R^2	0.222	0.215	0.230	0.207	0.195	0.216	0.624	0.536	0.636

Notes: "All" denotes all sectors, "Agric." denotes the agriculture and food sectors, while "Manuf." indicates the manufacturing sector. Robust standard errors clustered at the origin-destination-product level are in parentheses. ***, ** and * denote significance at 1%, 5%, and 10%. All models include controls for firm-origin-product, firm-product-year and destination-year fixed effects, which are excluded from the table for brevity.

> 1 within a country-product pair in year t, and 0 otherwise. We then replace the log of the count of NTMs with this dummy variable in Equation 4.1. The results which we present in Table A3 have, in most cases, the expected signs with magnitudes that are very small and also statistically insignificant. It is more intuitive to believe that the compliance cost increases with the number of NTMs (cumulative burden), as such what matters is not just the presence of NTMs but how many.

In the final robustness check, we re-estimate Equation 4.1 using an alternative fixed effect by replacing the firm-origin-product fixed effect with (1) firm-origin-destination fixed effect, which accounts for all time-invariant bilateral trade costs, and (2) firm fixed effect. In the first (second) case, our coefficient of interest is identified by exploiting the within firm-origin-product (firm level) changes in export values due to the variation in the number of NTMs imposed by the importing country on HS6-digit product p from origin c over time t. The results reported in Table A4, are qualitative similar to our baseline estimates (Table 2), although they are less precisely estimated. We note, however, that these estimates are not directly comparable to our main one as they are identified based on a different source of variation.

6 Conclusions

Despite sustained tariff concessions, African countries continue to play a marginal role in global trade. While tariffs have traditionally been a major focus of trade policy, NTMs, particularly standards and technical regulations, have emerged as a growing concern for policy makers, exporters, and importers alike. Despite their importance, relatively little is known about the impact of NTMs on firm-level exports in Africa, particularly in comparison to other regions. Hence, we bridge this gap in the literature by examining how NTMs influence firms' export strategies in Africa, utilizing data from selected African countries.

We explore the effect of non-tariff measures, specifically standards and technical regulations, which are fast replacing tariffs as the main trade policy tool, on the export margins of selected African countries. Specifically, we combine firm-product level customs transactions data on the universe of exporting firms in Senegal, Malawi, and Burkina Faso with data on NTMs in a reduced form gravity model of trade framework. We find no effect of standards and technical regulations on the extensive margin of trade in the sample of countries used in the study. On the other hand, we find that standards and technical regulations reduce trade at the intensive margins in both the agriculture and manufacturing sectors. This trade-reducing effect at the intensive margin is less pronounced for intermediate goods compared to consumable goods, as well as for large and medium-sized firms compared to small firms. Similarly, the trade-reducing effect is overturned for firms with relatively higher initial product quality in the manufacturing sector, while it is less pronounced for their counterparts in the agriculture sector. In addition, our findings indicate that the trade-reducing effect at the intensive margin does not vary by the level of development of the destination country, nor whether the export destination lies within or outside of Africa.

This paper enhances our understanding of the impact of NTMs on Africa's trade in several ways. Most existing studies have focused on the effects of NTMs on African exports at the country level, primarily within the agriculture sector. It is well-established in international trade literature that firms, rather than countries, are the main participants in international trade. Therefore, by using firm-level data, we can examine how NTMs influence the export decisions of African exporting firms. This approach allows us to determine whether firms adjust at the extensive margin or the intensive margin, consistent with trade models featuring heterogeneous firms. Additionally, unlike most previous studies on Africa, we consider both the agriculture and manufacturing sectors. Our findings reveal an unequal impact of technical measures on these sectors, with the agriculture sector being most affected. Moreover, the use of firm-level data enables us to study how the impacts differ by firm characteristics, in addition to product and destination characteristics.

Our empirical results have important policy implications. First, our findings suggest that standards and technical regulations are one of the barriers affecting the export performance of African firms. Specifically, these NTMs operate mainly as variable trade costs, such as expenses incurred during the transition from low-quality to high-quality products, thereby impacting trade at the intensive margin. However, the NTMs tend to disproportionately reduce export sales for low-productivity firms compared to medium and large-sized firms. This discrepancy arises because low-productivity firms are less equipped to absorb these additional compliance costs. Thus, implementing policies targeted at enhancing the productivity of small firms could help alleviate some of these costs for them.

Second, our finding that the trade-reducing impact of NTMs on the intensive margin is reversed for firms with comparatively higher initial product quality in the manufacturing sector, suggests that NTMs are not always trade-restrictive, particularly for such firms. By correcting market failures, standards play a pivotal role in boosting the export sales of firms that offer high-quality products. Hence, initiatives focused on upgrading product quality, such as incorporating high-quality intermediate goods into the production process, could assist firms in surmounting the obstacles presented by the imposition of NTMs.

Finally, our finding that the trade-restricting impact of NTMs does not depend on whether the export destination is within or outside Africa implies that African exporting firms are equally affected by NTMs in the regional market as they are in global markets. Therefore, initiatives aimed at eliminating NTMs under the African Continental Free Trade Area (AfCFTA), especially those that do not address market failure problems, thus becoming non-tariff barriers to trade, are a positive stride and hold substantial potential to boost intra-Africa trade.

The main caveat of our paper is that it is based on a limited sample of African exporting firms, and thus may not be fully representative of the entire population of African exporting firms. We are currently addressing this issue by employing a larger sample of exporting firms in Africa. An intriguing avenue for future research is to explore whether the relatively lesser impact of technical measures on intermediate goods has contributed to the increased participation of African exporting firms in global value chains. In addition, it would be worth examining whether harmonization of domestic standards with international standards positively impacts firm-level export margins in Africa.

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Appendix

Table A1: Summary statistics

Variable	Mean	SD	Min	Max	N
Export value (USD)	346103.824	2825592.824	0.002	253420134	101379
Export volume (kg)	626072.285	11186611.105	0.02	978977400	101379
Tariff (%)	1.432	6.28	0	200	101379
NTM_{pcdt}	1.020	4.273	0	118	101379
TBT_{pcdt}	0.415	1.157	0	35	101379
SPS_{pcdt}	0.605	3.875	0	117	101379

A1 Estimating product quality

Critical to this part of the analysis is how we measure unobservable "product quality". It is standard in the agricultural trade literature to use prices (measured as unit values) to proxy quality (Fernandes et al., 2019). For each HS6 digit product p, the bilateral trade data records the total nominal value of imports in US dollars from a given exporter, as well as the quantity in tonnes associated with these imports. Taking the ratio of trade values and trade quantities, we obtain so-called unit values, i.e., $p_{ijpt} = v_{ijpt}/q_{ijpt}$. While unit values are available for a wide range of products and countries, they may not be precise proxies for quality. Prices may also reflect higher production costs, exchange rates or market power. Our approach follows Khandelwal et al. (2013) and recovers quality directly from observed trade data as follows. Consider the following CES utility function, which expresses the preferences of consumers for a variety ν in country j, assuming that consumers' preferences incorporate quality:

$$U = \left[\int_{\nu \epsilon V} \left[\lambda(\nu) q(\nu)\right]^{\frac{\sigma-1}{\sigma}} d\nu \right]^{\frac{\sigma}{(\sigma-1)}} \tag{A1.1}$$

where $q(\nu)$ is the consumed quantity of ν and $\lambda(\nu)$ is its quality, while $\sigma > 1$ is the elasticity of substitution parameter which is assumed to be constant. Maximizing (A1.1) under the usual budget constraint gives the demand of consumers in country j for product p exported by firm f in country i as depending on the price and quality of the product, prices of substitute products and on the income of the consumer, yielding:

$$q_{fijpt} = \lambda_{fijpt}^{\sigma-1} P_{fijpt}^{-\sigma} P_{jt}^{\sigma-1} Y_{jt} \tag{A1.2}$$

where P_{fijpt} and λ_{fijpt} are the price and the relative quality attributed by country j, to product p, exported by firm f in country i, respectively. The terms P_{jt} and Y_{jt} account, respectively, for the importing countries' price index and income level. Log linearising equation (A1.2) and moving the endogenous price to the left-hand side of the equation we can estimate the quality for each country-product–year as the residual from the following ordinary least squares (OLS) regression:

$$\ln q_{fijpt} + \sigma_{jk} \ln p_{fijpt} = \alpha_p + \alpha_{jt} + e_{ijpt} \tag{A1.3}$$

where q_{fijkt} and p_{fijkt} are, respectively, the quantity and the price (unit value) of product k, exported by firm f in country i to country j at time t. α_k are product fixed effects that capture differences in prices and quantities across product categories due to the inherent characteristics of products. α_{jt} are importer-year fixed effects that account for both the destination price index P_{jt} and income Y_{jt}. Estimating (A1.3) separately for each country and HS4-digit industry, the estimated quality is given as

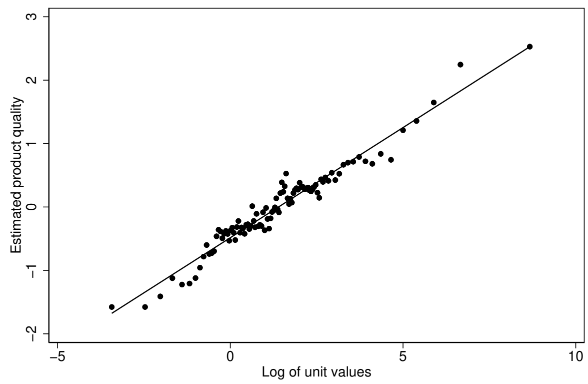
$$\ln \hat{q}_{fijpt} \equiv \hat{e}_{fijpt}/(\sigma_{jp} - 1) \tag{A1.4}$$

We allow the elasticity of substitution to differ across HS3-digit product classes using data from Broda et al. (2017).

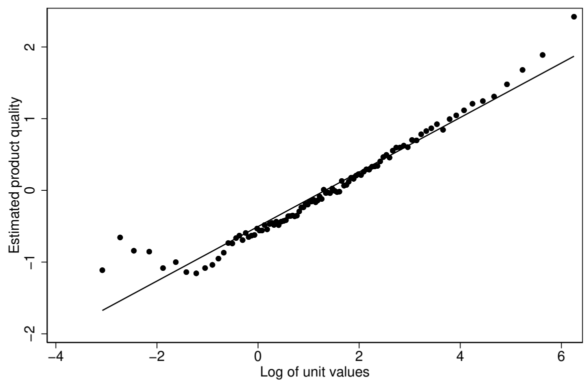
The intuition behind the Khandelwal et al. (2013) approach is simple: conditional on prices, varieties with higher quantities (market shares) are assigned higher quality.[18] We assume the quality is any attribute that raises consumer demand other than price (Khandelwal et al., 2013; Disdier et al., 2023). After estimating quality $\hat{q}_{fijpt}$, we obtain the quality-adjusted price component as the observed log prices less estimated quality, i.e., $\ln \hat{p}_{fijpt} = \ln p_{fijpt} - \ln \hat{q}_{fijpt}$. That is the differences in product prices for the same level of quality.

[18] For instance, suppose bananas from Ecuador and Colombia are equally priced, but Colombia's market share in the destination market j is 20% and Ecuador's is 10%, the quality estimate for Colombia will be higher. If bananas from Colombia were more expensive, then we would need to control for the price difference and this would reduce the quality estimate for Colombia.

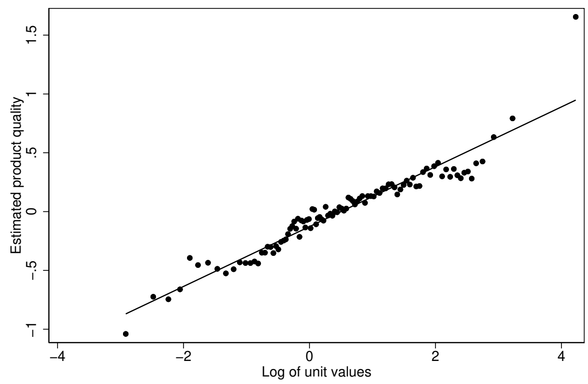
Figure A1: Relationship between unit values and estimated product quality



(a) All sectors



(b) Manufacturing



(c) Agriculture

Notes: All the figures present binned scatter plots of estimated product quality a la Khandelwal et al. (2013) and unit values. All values are divided into 100 equal-sized groups, with each dot representing the mean value within each bin. In each plot, the line shows the best linear fit estimated via OLS.

A2 Results from the PPML estimator

In this section, we estimate the model using the Poisson pseudo-maximum likelihood (PPML) estimator. The estimator's log-linear objective function allows us to specify the gravity equation in its multiplicative form without log-transforming the dependent variable and is consistent under heteroskedasticity (Silva and Tenreyro, 2006). The estimation equation is as follows:

$$y_{icpdt} = \exp\left[\beta_0 + \beta_1 NTM_{pdt} + \beta_2 \ln Tariff_{cpdt} + \omega_{cpd} + \lambda_{ct} + \gamma_{dt}\right] + \epsilon_{icpdt}, \tag{A2.1}$$

Where the variables remain as defined in Equation 4.1. However, the dependent variables, i.e., trade values and trade volumes are not log-transformed.

Table A2: PPML results for the effect of NTMs on the intensive margin of trade

Dependent variable:	Export Value (logs)			Export Quantity (logs)		
	All	Agric.	Manuf.	All	Agric.	Manuf.
	(1)	(2)	(3)	(4)	(5)	(6)
log NTM_{pcdt}	-0.260^{**}	-0.323^{***}	-0.695^{**}	-0.383^{*}	-0.225^{*}	-0.746
	(0.115)	(0.125)	(0.326)	(0.204)	(0.133)	(0.564)
log $Tariff_{pcdt}$	0.053	0.131^{***}	-0.102^{*}	0.028	0.065	-0.016
	(0.043)	(0.042)	(0.062)	(0.055)	(0.050)	(0.098)
Observations	374,784	133,846	237,131	374,784	133,846	237,131

Notes: "All" denotes all sectors, "Agric." denotes the Agriculture and food sectors, while "Manuf." indicates the Manufacturing sector. Robust standard errors clustered at the origin-destination-product level are in parentheses. ***, ** and * denote significance at 1%, 5%, and 10%. All models include controls for firm-origin-product, firm-product-year and destination-year fixed effects, which are excluded from the table for brevity.

A3 Considering the presence of NTMs instead of the count of NTMs

In this section, we define our variable of interest as an indicator of the presence of an NTM instead of the count of NTMs. The downside of using an indicator variable is that we implicitly assume that the effect of one NTM is not different from the effect of several NTMs. It is more intuitive to believe that the compliance cost increases with the number of NTMs (cumulative burden).

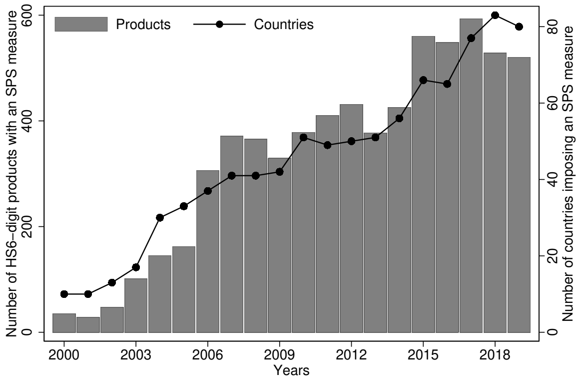
Table A3: The effect of non-tariff measures on firm-level export margins by firm size

	Extensive margins						Intensive margin		
Outcome:	Export Entry Dummy			Export Exit Dummy			Export Value (logs)		
	All	Agric.	Manuf.	All	Agric.	Manuf.	All	Agric.	Manuf.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
NTM_{pcdt}	−0.000	0.001	0.000	−0.001	0.000	0.000	0.006	0.000	−0.022
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.059)	(0.142)	(0.060)
log $Tariff_{pcdt}$	−0.000	−0.000	−0.000**	−0.000	−0.000	−0.000*	0.012	0.033	−0.019
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.016)	(0.033)	(0.015)
Observations	1,319,162	403,212	915,479	1,392,332	425,985	965,843	101,379	39,502	61,265
Adjusted R^2	0.217	0.202	0.227	0.210	0.191	0.220	0.631	0.541	0.646

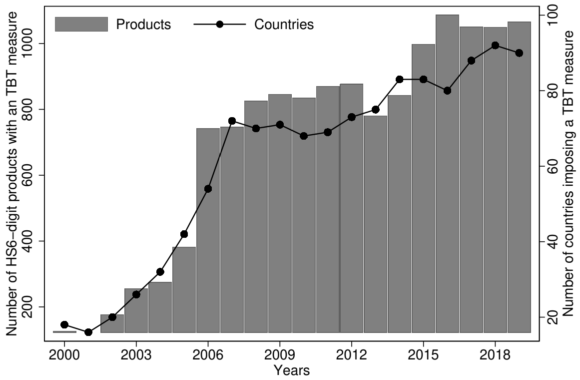
Notes: "All" denotes all sectors, "Agric." denotes the agriculture and food sectors, while "Manuf." indicates the Manufacturing sector. Robust standard errors clustered at the origin-destination-product level are in parentheses. ***, ** and * denote significance at 1%, 5%, and 10%. All models include controls for firm-origin-product, firm-product-year and destination-year fixed effects, which are excluded from the table for brevity.

A4 Additional figures

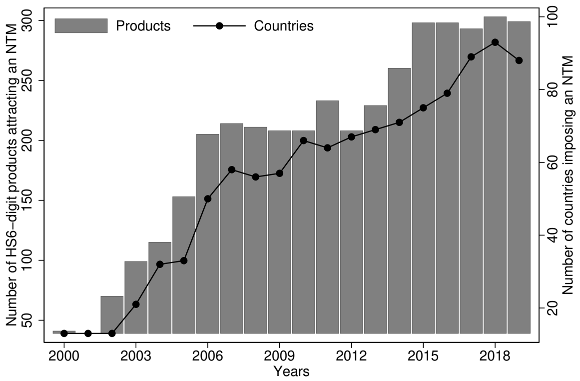
Figure A2: The proliferation SPS and TBT measures over time and across sectors



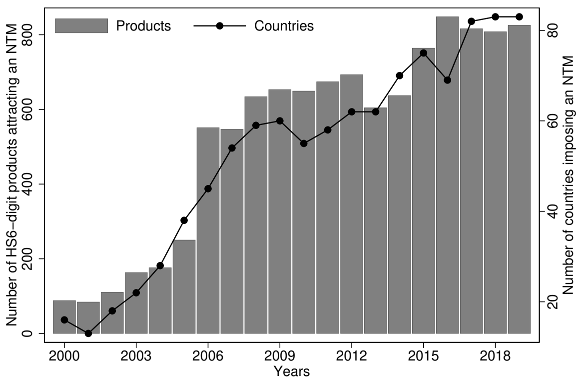
(a) SPS measures



(b) TBT measures



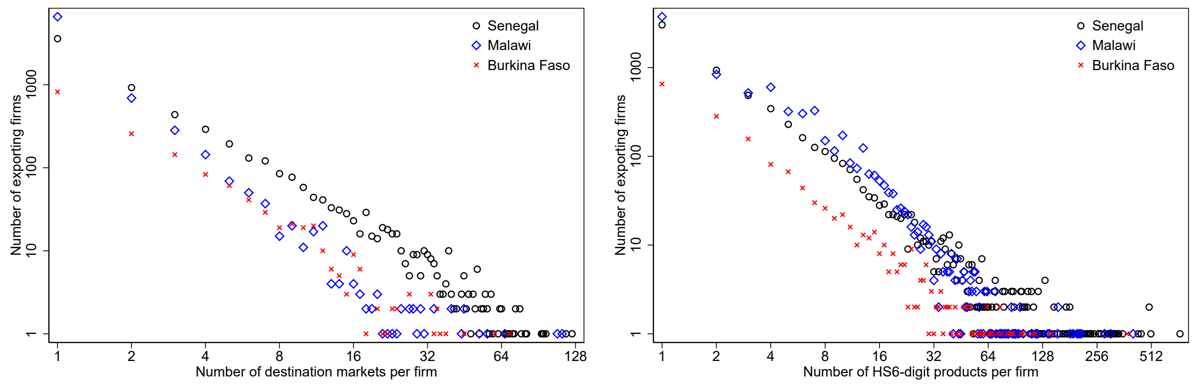
(c) Agriculture sector



(d) Manufacturing sector

Notes:

Figure A3: Firms, destination markets and HS6-digit products



(a) Number of destinations

(b) HS6-digit products

Notes:

Table A4: Effect of NTMs on the intensive margin of trade: Alternative fixed effects

Outcome:	Export Value (logs)					
	All	Agric.	Manuf.	All	Agric.	Manuf.
	(1)	(2)	(3)	(4)	(5)	(6)
log NTM_{pcdt}	-0.100^{**}	-0.195^{**}	-0.104^{*}	-0.070^{*}	-0.166^{*}	-0.125^{**}
	(0.041)	(0.098)	(0.061)	(0.041)	(0.085)	(0.063)
log $Tariff_{pcdt}$	-0.004	0.037	-0.021	0.012	0.035	-0.019
	(0.012)	(0.028)	(0.013)	(0.016)	(0.033)	(0.015)
Observations	88,879	33,373	53,434	101,379	39,502	61,265
Adjusted R^2	0.741	0.682	0.744	0.632	0.542	0.646

Notes: "All" denotes all sectors, "Agric." denotes the agriculture and food sectors, while "Manuf." indicates the manufacturing sector. Robust standard errors clustered at the origin-destination-product level are in parentheses. ***, ** and * denote significance at 1%, 5%, and 10%. Columns 1 to 3 include controls for firm-origin-destination, firm-product-year and destination-year fixed effects. Columns 4 to 6 include controls for firm, firm-product-year and destination-year fixed effects