Heterogeneous Impact of Non-tariff Measures on Trade Margins through Global Value Chains

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Abstract

Technical measures, such as sanitary and phytosanitary measures and technical barriers to trade were prevalent in the past decades and have induced an increasing number of trade disputes among countries. This study investigates the impact of technical measures on Chinese firms' margins of trade and trade unit values by focusing on how these impacts vary across firms with different positioning in the global value chains (GVCs). The analysis relies on panel data of Chinese firm-level imports over 2008–2013 and an original dataset on non-tariff measures provided by the United Nations Conference on Trade and Development (UNCTAD). The results show that the impact of technical measures differs across importer positioning in the GVC. While importers with a small downstreamness are negatively impacted by both intensive and extensive margins, technical measures benefit the firms located further downstream in the global input market at the expense of new entrants. Further, I find evidence that products subjected to more technical measures are imported at a higher price, while firms with larger downstreamness are able to mitigate a rise in prices.

JEL Classification: F13, F14, F15

Keywords: Global value chain; Non-tariff measure; Margins of trade

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1. Introduction

While there is an acceleration in the reduction of trade barriers in the past decades, non-tariff measures (NTMs) have spread in the world and among them are technical measures (TMs), such as sanitary or environmental protection measures as well as traditionally used commercial policy instruments. TMs refer to product-specific properties such as characteristics, technical specifications, and production processes of a product. They also include conformity assessment methods, which affirm the compliance of a product to a given requirement. These technical regulations are generally aimed at ensuring food quality and safety, environmental protection, and national security and protecting animal and plant health (UNCATD, 2019). The rapid growth of TMs has induced a large literature on their effects on trade. In particular, it is said that TMs increased significantly in the 1970s and 1980s when tariff reduction was progressing. Even though TMs are not discriminatory measures (as they impose the same restrictions on both foreign and domestic firms), many of them are recognized as pure trade barriers that cause more economic damage than tariffs, and their removal for welfare improvement is being advocated. Indeed, product varieties are restricted because some foreign exporters are rejected from domestic markets due to additional compliance costs. As a result, consumers may be affected negatively because their preferred varieties are excluded from the market while the prices of the remaining varieties increase (Disdier et al., 2018).

While early studies warned about the dangers of marginalization of the poor with increasing standards, recent studies do not necessarily treat TMs as trade barriers and document their positive effects on household income, risks, income variability, technology adoption, and quality of produce because TMs establish common rules and standards that promote trade and prevent risks to health and safety, thereby promoting the welfare of consumers (Beghin et al., 2015). As a result, existing evidence from studies investigating the effect of TMs on welfare, trade, industrial organization, and labor markets, is mixed because TMs can promote or impede trade and economic growth, which possibly reflects their compounding effects on industries and firms. This is partly because unlike tariffs in which the extent of the barrier is reflected by the tariff rates, the stringency of restriction caused by TMs is not evident and in many cases the rules of TM are not always clearly defined causing arbitrary interpretations and non-uniform operations. Regarding the effect of TMs on trade, introducing an NTM may increase the fixed cost of entering a market involved in the upgrading of facilities, acquiring certificates, and conforming to marketing requirements (Martin, 2012). Furthermore, TMs can also raise variable costs by imposing the costs to upgrade the products or substitute the intermediates of producing the exported goods. More importantly, TMs may not only induce a deadweight loss to the importing economy (as tariffs do), they could also be welfare-improving by addressing market failures such as information asymmetry between consumers and producers with respect to quality, safety and other product characteristics[1], making the overall effect of TMs depends on the balance of the cost-inducing and the demand-enhancing effects.

On the other hand, the rising fragmentation of production in the global value chain (GVC) has been a key trend in international trade and the division of labor in the GVC has been gradually replacing the traditional form of division of labor. With the help of revolutionary breakthroughs, cross-integration of information technology, new materials, and new sources of energy the pattern of global manufacturing development has changed. That is, world production is now structured into global value chains. The regional decentralization of production has led to the rise of trade in intermediate goods (especially in the field of manufacturing), which is transforming the mode of production from “made in one country” to “made in the world,” and the mode of trade from

[1] As the “lemons problem” by Akerlof (1970) indicates, product quality would degrade in an information asymmetry context as buyers are only able to observe the average product quality, so that high-quality products are forced out of the market by low-quality ones. Therefore, by dealing with the information asymmetry, the introduction of specific TMs should increase the quality of products that are actually consumed.

"trade in goods" to "trade in tasks" (WTO & IDE-JETRO, 2011). Having been deeply involved in the division of GVC, the Chinese manufacturing industry is rapidly developing. According to the World Input-Output Database (WIOD), China's manufacturing industry has been growing at an average annual rate of 17.32% since 1995 and its output reached 175 billion US dollars in 2010, accounting for 14.10% of the global manufacturing output.

Research on positioning in the GVC has made progress in recent years. In Antràs and Chor (2013), who are pioneers in the field, the upstreamness index of an industry was measured by the number of stages in a production chain, up to the final consumer in the industry. Similarly, Fally (2012) composed the GVC measure based on the concept that "if the product of the industry is used in an industry far from the final consumer in the value chain, the industry is located upstream." Antràs et al. (2012) proved that Fally's (2012) composition was identical to that of Antràs and Chor (2013). By using the upstreamness index, one can analyze the spillover effects of economic shocks in one country on the economy of another. For example, if a major industry in a country is located upstream in the GVC, production, and exports in that country will be more susceptible to demand shocks in countries located downstream in the GVC. Therefore, to consider the economic impact of these policies on the country, it is important to understand which country is located downstream of the country in the GVC. Besides, it is important to compare the positioning of each country in the GVC with the benefits obtained from trading with that country to examine the competitiveness of the industry at the national level. Building on the methodology in Antràs et al. (2012) and Fally (2012), Alfaro et al. (2019) further constructed firm-level upstreamness measures of integrated and nonintegrated inputs.

Taking China as an example, since Chinese firms have been playing a leading role in the global processing trade, the imposition of TMs would have a significant effect on the trade pattern of Chinese firms: stricter TMs imposed by China will hinder the upstream suppliers in foreign countries export intermediate inputs to the Chinese buyers. The further away the position in the GVC from the Chinese market (i.e. the more upstream the supplier is or the more downstream the demander is from Chinese firms), the more difficult it becomes to grasp the components subject to TM regulations. This is because longer distances in the GVC indicates that more markets with different environment of TMs exist between China and the traders, in other words, the net effect of TMs becomes harder for one to foresee. What makes the question more complex is that even for firms facing similar TMs, the effect of TMs on those firms would vary depending on the firms' positioning in the GVC. A specific firm can choose to import different types and different quantities of products from foreign suppliers so that each firm may have unique positioning in the GVC. Under this situation, firms facing the same type and the same stringency of TMs will receive different impact if they have different compositions and values of import.

In this study, I investigate the impact of stringency of TMs on Chinese firms' margins of trade and trade unit values by paying special attention to how the impact varies across firms with different positioning in the GVC. The empirical analysis relies on the panel of Chinese firm-level imports over the 2008–2013 period, an original dataset on NTMs provided by the United Nations Conference on Trade and Development (UNCTAD), along with the industry level input-output dataset provided by the WIOD. My empirical strategy is to investigate Chinese importers' behavior in terms of the value of product, trade participation, and price-setting as a function of TM regulation and a series of firm characteristics, especially the firm's positioning in the GVC. The intersection term between the measure of TMs and the firm's GVC positioning is employed to observe the heterogeneous impact of TMs. I also control for bilateral tariff levels and a set of fixed effects to control for the unobservable factors affecting trade.

This study contributes to the literature in the following ways. First, this study captures the stringency of TMs through a continuous measure. The UNCTAD Trade Analysis Information System (TRAINS) database provides comprehensive information on NTMs by country, product, and year, which enables me to construct a continuous variable that effectively plugs the gap in existing literature, claiming that the impact of TMs can only be measured by discrete dummy variables that reflect the existence of TM impositions (e.g., Crivelli & Groeschl, 2016; Curzi et al., 2020). Second, existing studies on the impact of NTMs do not consider the GVC. As the GVC may deliver heterogeneous impacts of trade policy on firms playing different roles in the international trade market, I add to the literature by controlling for the firm-level GVC positioning during the estimation. Third, most literature on the impact of NTMs run either the cross-sectional estimation on firm-level microdata or the panel estimation on country-level macro data, mainly due to the limited data. Combining the microdata of the firm's trade and the data on country-product level NTMs, this study fills the gap by running a panel analysis on firm-level trade performance. Finally, existing micro-level analysis on the impact of NTMs focuses on developed economies, including France (Fontagné et al., 2015), the United States (Grundke & Moser, 2019), and Japan (Yang et al., 2019), leaving the effect of NTMs in developing countries unexplored. This study is to the best of my knowledge the first to investigate the relationship between NTMs and trades relying on the panel data on China -the world's largest developing country and the largest importer of processing products.

The results show that while the imposition of TMs reduces the participation of firms in the international import market, the import value of those firms can be stimulated, which indicates that while TMs pose an obstacle to market entry; producers who meet the regulations are able to increase their trade flows due to decreased market competition caused by the TMs. Furthermore, the impact varies across firms depending on the positioning in the GVC because the high degree of connection with the GVC can benefit the firm's import. Additionally, the results provide the empirical evidence that shows the price-raising effect of TMs, indicating that the additional costs caused by TMs may represent an incentive for firms to upgrade their imports.

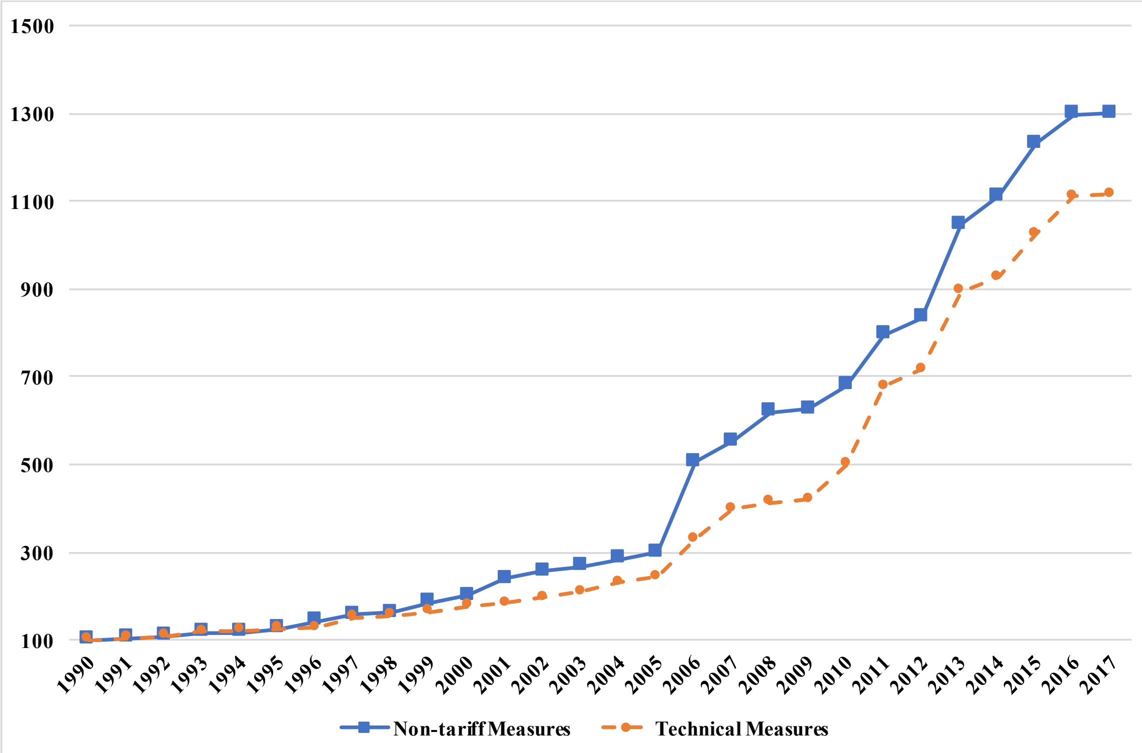
The remainder of this paper is organized as follows: Section 2 provides a brief review of the background. Section 3 discusses the data and construction of variables of interest, along with the empirical model. Section 4 provides the estimation results and discussion. Section 5 concludes.

2. Background and Related Literature

2.1 NTM Regulations

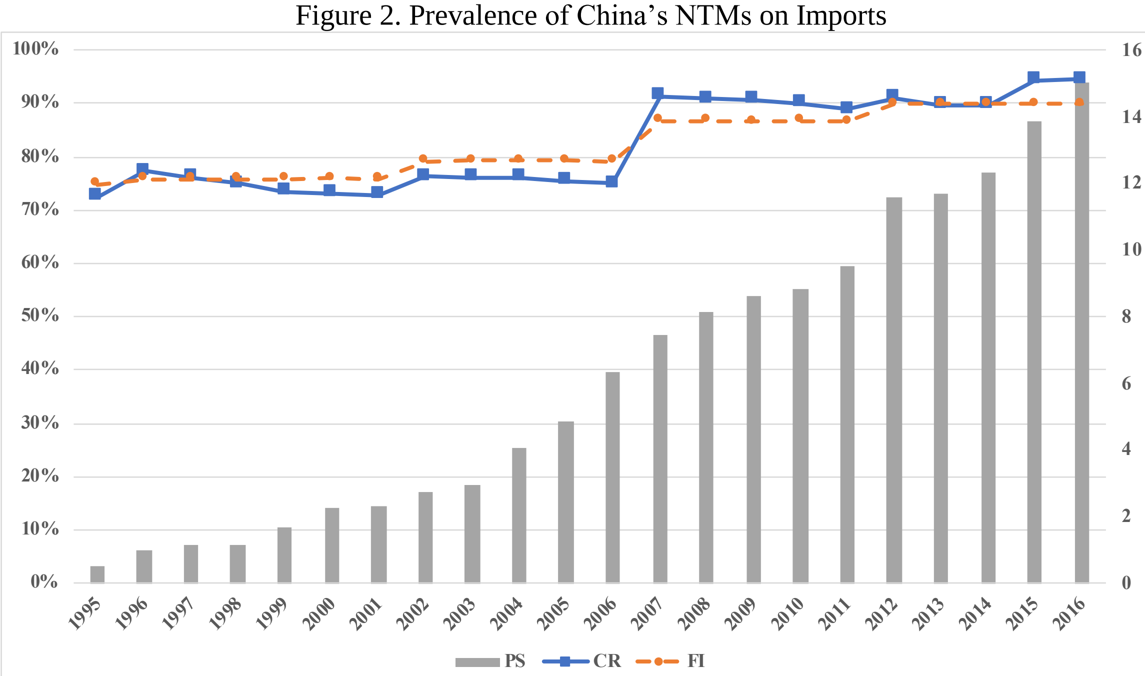
In light of decreasing tariffs, quotas, and prohibitions due to multilateral and bilateral agreements over the last decades, NTMs appear to be on the rise (WTO, 2012). Figure 1 illustrates the number of global NTMs and TMs that are in force (denominated as the year of 1990=100) during the 1990–2017 period. The two upward lines suggest that NTMs and TMs have become increasingly prevalent over the period. Figures 2 and 3 respectively depict the prevalence of NTMs and TMs in China's imports by providing the coverage ratio (CR), the frequency index (FI), and the prevalence score (PS). The right axis denotes the number of NTMs and TMs applied on the HS (Harmonized System) 6-digit product, while the left axis shows the percentage of trade or product subject to NTMs. Between 1995 and 2016, the coverage ratio, the frequency index, as well as the prevalence score increased considerably, indicating that NTM measures have been affecting a broad range of imports in China.

Figure 1. Prevalence of World's NTMs and TMs (1990=100)



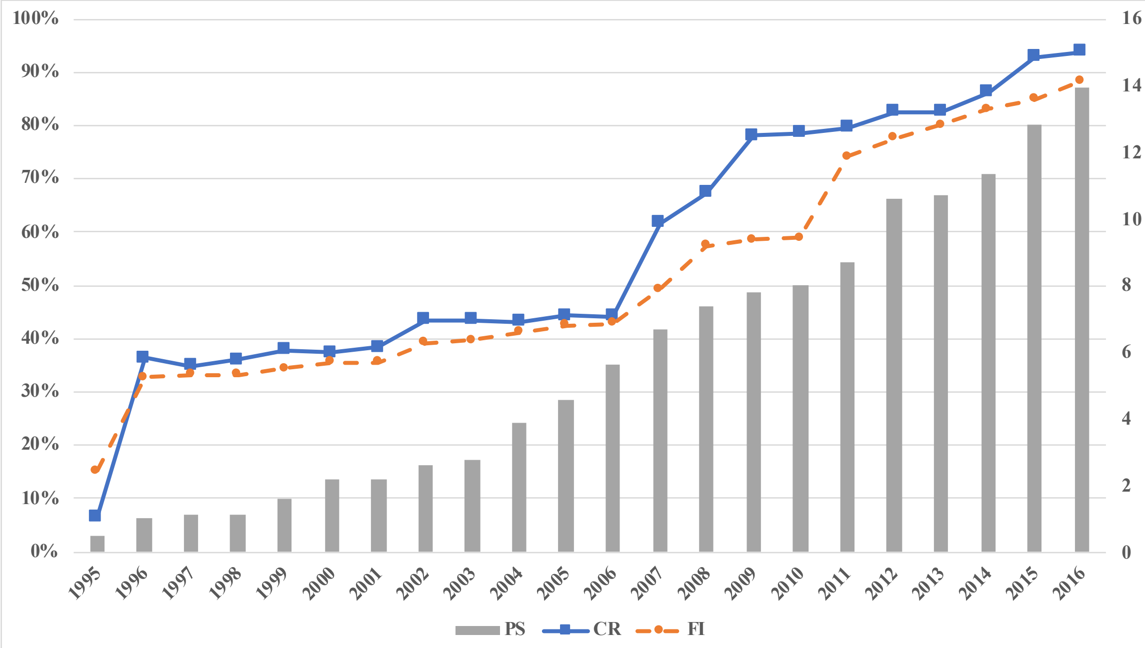
Note: The number of NTMs is the cumulative ones that are in force as of each year.
Source: Author's calculations on the UNCTAD TRAINS database.

Figure 2. Prevalence of China's NTMs on Imports



Source: Author's calculations on the UNCTAD TRAINS database and UN Comtrade.

Figure 3. Prevalence of China's TMs on Imports



Source: Author's calculations on the UNCTAD TRAINS database and UN Comtrade.

Existing studies have attempted to capture the effect of NTMs with different methodologies. Devadason et al. (2018) examined the prevalence of NTMs in Malaysia's food industries and then estimated their impact on food imports from ASEAN. Besides the measures that capture unilateral stringency of a country's NTMs, there are alternative indicators to evaluate regulatory differences between countries at the product level. Drogué and DeMaria (2012) used Pearson's distance to measure the dissimilarity between vectors representing a series of MRLs set on apples and pears. Although the Drogué and DeMaria (2012) indicator is calculated to be symmetric between a given pair of countries, Winchester et al. (2012) propose a directional indicator to capture the relative stringency of a series of maximum residue levels (MRLs) affecting animal and plant products in the destination compared to the country of origin in each trade flow. Yang et al. (2019) further applied the relative stringency measure of MRLs to the Japanese poultry market and tested the effect of the pesticide residue standards on poultry consumption using a structure estimation model. Although these indicators build on the quantitative information of MRLs affecting specific groups of products, Cadot et al. (2015) and Cadot and Ing (2015) propose regulatory distance measures based on the qualitative information of the various types of regulations. Additionally, there is literature that estimates the impact of NTMs on international trade. Fontagné et al. (2015) and Fernandes et al. (2019) show that TMs increase the probability and quantity of export for firms with higher productivity at the expense of firms with lower productivity. Fontagné and Orefice (2018) further show that the negative effect of TMs on the probability of export is magnified for multi-destination firms, which can divert their exports towards NTM-free destinations.

2.2 Global Value Chain

By dramatically altering the international organization of production, the rise of GVCs has emphasized the specialization of each country within the GVC (Antràs & Chors, 2018). There are several important issues where theoretically and empirically focused on the position in the GVC. Alfaro and Charlton (2009) found that multi-national firms choose to own proximate stages of production. Antràs and Chor (2013) developed a property rights model in which a firm's boundaries are shaped by characteristics of the different stages of production and their position along the GVC. Alfaro et al. (2019) developed Antràs and Chor (2013)'s framework to a richer model of firm behavior that can guide an empirical analysis using firm-level data. They found that whether a firm integrates suppliers located upstream or downstream depends crucially on the elasticity of demand faced by the firm. The interpretation of GVC is not clarified until Antràs (2019) defined it as a series of stages involved in producing a product or service that is sold to consumers, with each stage adding value, and with at least two stages being produced in different countries. Antràs (2019) further defined a firm's participation in the GVC as the involvement of production in at least one stage in a GVC.

Empirical studies on the international competitiveness of the manufacturing industry can be roughly divided into two categories according to different trade accounting systems: first, analysis of traditional trade index. Balassa (1965) proposed to use the revealed comparative advantage index to measure the international competitiveness of a country's industry. Since this approach ignored the import factor, subsequent studies further proposed the trade competitiveness index, which measures the international competitiveness of a country's industry by the proportion of the net trade of a country's industry to the total trade. The second category is the value-added trade index analysis. Hummels et al. (2001) proposed the vertical specialization index (including forward and backward vertical specialization index) to measure the division of labor of a country's industry in the GVC. Koopman et al. (2010) put forward the GVC participation index and the GVC positioning index to measure the division of labor of a country's industry in the global value chain[2], which was further developed by Wang et al. (2017) who proposed a pair of GVC participation indices that improve upon the measures in the existing literature. Antràs and Chors (2013) estimated the average position of a country's industry in the GVC by constructing industry upstreamness and downstreamness index based on the US input and output table. Recent studies have developed various theoretical frameworks, emphasizing the operational influence of the rise of the GVC on the general equilibrium model of international trade. These measures envision a world in which production in the GVC features some element of sequentiality, among them is the term "snakes" given by Baldwin and Venables (2013) referring to purely sequential value chains, in which each production stage obtains its inputs from a unique upstream stage. The other term called "spiders" they introduced describes a flatter GVC in which each production stage sources inputs from several upstream suppliers simultaneously.

2.3 Chinese Manufacturing Firms

Since its accession to the WTO in 2001, China's rapid growth in international trade has been remarkable. According to WTO's World Trade Statistical Review, China's share in world exports grew from 5.9% in 2003 to 13.1% in 2018. Furthermore, the United Nations Statistics Division shows that China accounted for 28% of global manufacturing output in 2018, making the country more than 10% points ahead of the United States, which used to have the world's largest manufacturing sector until China overtook it in 2010. Shi (2011) indicated that China's growth in exports is mainly driven by quantity growth, which is the growth in intensive margins, which accounts for about 70% of overall export growth. Studies also found the evidence of the "learning effect" of export. That is, firms start exporting exhibit better performance (prior to commencing exports) than non-exporting firms. Brandt et al. (2012) supported the growth of productivity, in which they found that the average annual growth in productivity of Chinese manufacturing firms is 2.85% for a gross output production function and 7.96% for a value-added production function over 1998–2007, which is among the highest compared to other countries. Regarding the role in the GVC, China consistently occupies the most upstream (resp. downstream) position along the

[2] Studies related to the GVC participation index who referred to Koopman et al. (2010) include, for example, Sun et al. (2019). Sun et al. (2019) evaluated carbon efficiency and the GVC position index to further analyze the impact of position of manufacturing in the GVC on carbon efficiency using panel data of 60 countries from 2000 to 2011.

global output supply (resp. input demand) chain, mainly due to a large share of manufacturing output in its gross output (Miller & Temurshoev, 2017).

During the empirical analysis on China's economic growth, some firm-level databases have been frequently employed, among them is the Chinese Customs Trade Statistics (CCTS)[3]. Upward et al. (2013) quantitatively measured the domestic value-added in China's manufacturing exports in line with Hummels et al. (2001)'s framework and provided an assessment of the export boom in China from 2000 to 2007. Kee and Tang (2016) provided micro-level evidence of China's increasing ratio of domestic value-added in exports to gross exports. Lu et al. (2018) calculated the ratio of foreign value-added to measure the GVC participation of Chinese exporting firms from 2000 to 2006. Defever et al. (2020) used a combined dataset consisting of the CCTS to investigate the role played by wholesaling services in the manufacturing sector to determine firm productivity during periods of input trade liberalization. Amiti et al. (2020) analyzed the effect of China's expansion of exports following its WTO entry on the prices of manufacturing goods in the U.S. between 2000 and 2006.

3. Data and Empirical Strategy

3.1 GVC Downstreamness Index

I employ the measures introduced in Antràs and Chor (2018), whose framework referred to Antràs and Chor (2013) and Fally (2012) to gauge the relative location of an industry in the international input market. The downstreamness index is defined as the distance between the industry and the primary factors of production. Other things being equal, an industry has a high downstreamness if its production process uses lesser value-added relative to intermediate inputs, particularly when it purchases intermediate inputs from industries that themselves use intermediate inputs intensively. Conversely, if an industry relies largely on value-added from primary factors of production, then the industry will be relatively upstream of the international input market. The detailed derivation and interpretation of the index are given as follows.

Assuming an N-industry closed economy with no inventories, the value of gross output of industry *i* at year *t* (denoted by Y_{it}) equals the sum of all intermediate purchases in countries *i* (denoted by Z_{it})and the value-added employed in the production of industry *i* itself at year *t* (denoted by VA_{it}). That is, Y_{it} can be written as:

$$Y_{it} = Z_{it} + VA_{it}. \quad (1)$$

Defining $d_{ijt} = Z_{ijt}/Y_{it}$ as the share of industry *i*'s output that is used in industry *j* at year *t*, Eq. (1) can be expressed as:

$$Y_{it} = \sum_{j=1}^{N} d_{ijt} Y_{jt} + VA_{it}. \quad (2)$$

Iterating this identity, industry *i*'s output at year *t* can be expressed as an infinite sequence of terms that reflect the use of this industry's input at different positions in the GVC, which can be written as:

$$Y_{it} = \sum_{j=1}^{N} d_{ijt} VA_{jt} + \sum_{j=1}^{N}\sum_{k=1}^{N} d_{ikt} d_{kjt} VA_{jt} + \sum_{j=1}^{N}\sum_{k=1}^{N}\sum_{l=1}^{N} d_{lkt} d_{kjt} VA_{jt} + \cdots + VA_{it}. \quad (3)$$

Notice that the first term reflects the use of intermediate inputs that are produced directly with primary factors. The second term captures intermediate input purchases produced with inputs produced with primary factors, and so on. The larger the terms associated with further iterations, the more intensive is that country-industry's use of inputs far removed from primary factors, and thus the production is more downstream relative to these primary factors. Finally, the last term captures the direct use of primary factors in the production of industry *i* at year *t*.
Multiplying each term in Eq. (3) by the distance from the primary industry plus one and dividing by Y_{it}, the average position of an industry's input in the GVC can be derived as:

[3] See Section 3.3 for detailed description.

$$Down_{it} = 1 \cdot \frac{VA_{i_{it}}}{Y_{it}} + 2 \cdot \frac{\sum_{j=1}^{N} d_{ijt} VA_{jt}}{Y_{it}} + 3 \cdot \frac{\sum_{j=1}^{N} \sum_{k=1}^{N} d_{ikt} d_{kjt} VA_{jt}}{Y_{it}} + \cdots. \quad (4)$$

It is obvious that $Down_{it} \geq 1$, and that higher values are associated with relatively higher levels of downstreamness in the global input market. As indicated by Miller & Temurshoev (2017), industry's GVC downstreamness is identical to its total backward linkage expressed in terms of gross output. The nature is that industries with a high total backward linkage will purchase a disproportionate part of their intermediate inputs from the upstream industries, and it is this kind of purchase that places industries with a high total backward linkage to a downstream position in the global input market.

After deriving the industry-level $Down_{it}$, I convert these indices into firm-level indices based on Chor et al. (2014) to infer the downstreamness of imports of each firm in China. The downstreamness of firm *f*'s imports is defined as:

$$Down_{ft}^{M} = \sum_{i=1}^{N} \frac{M_{fit}}{M_{ft}} Down_{it}. \quad (5)$$

Here, $M_{ft} = \sum_{r=1}^{N} M_{frt}$ is the total imports within industry *i* of firm *f*. It is necessary to stress the distinction between the industry-level downstreamness $Down_{it}$ and the firm-level one $Down_{ft}$. The industry-level downstreamness is derived from the input-output table that contains information on industry-level linkages of all countries in a full production network so that the index indicates the positioning of a certain industry, whereas the firm-level downstreamness is calculated as the value-weighted average of the industry-level index using the share of imports of each industry to capture the importance of that industry in firm *f*'s imports. Therefore, instead of a definite positioning in the world input chain, a high firm-level downstreamness indicates that it purchases a substantial amount of input that belongs to industries with high downstreamness, and conversely, a low firm-level downstreamness indicates that the inputs are purchased from industries with a low downstreamness.

I compute the GVC positioning indices using the World Input-Output Tables (WIOTs) for the 2000–2014 period available from the European Union-funded World Input-Output Database (WIOD) project[4][5]. This database provides panel information on the global input-output tables for 27 EU countries, 13 other major countries, and the rest of the world (ROW)[6]. For each country, the input-output data for 56 sectors are classified according to the International Standard Industrial Classification Revision 4 (ISIC Rev. 4). See Table A1 for detailed description on the included industries. Utilizing this information, the GVC positioning indices are responsible to capture the average position of each country-industry in the production chains in which it is involved (Antràs & Chor, 2018). Although my subsequent goal is to convert the industry-level indices into the firm-level ones using microdata from China, it is necessary to capture the linkage of China with the rest of the world using the world's input-output table. Thus, I first need to derive the industry level GVC positioning indices of all countries in the database and then extract those of Chinese industries for further calculation of firm-level ones.

3.2 Non-tariff Measure Database

[4] The WIOD Input-output database is documented in Timmer et al. (2015) and is available at http://www.wiod.org. In this paper, I utilize the World IO Tables released in 2016. For a detailed description of the database construction, see Timmer et al. (2016).

[5] A global IO table was developed by the Institute of Developing Economies-Japan External Trade Organization (IDE-JETRO). Although the IDE-JETRO international IO table covers other Southeast Asian countries, including Thailand, and is available from 1985, it is only available at five-year intervals (2005 is the latest year available). Its industry classification is less detailed (covering 24–26 industries) than that of the WIOD (which covers 56 industries) and is not harmonized throughout the period. Consequently, this paper utilizes the WIOD.

[6] The 13 countries include non-EU OECD member countries, including Japan and the US, and emerging economies including China, Indonesia, and Mexico. The detailed list for countries is given by Table A2.

The empirical analysis relies on the TRAINS NTM database carried out by the UNCTAD. The TRAINS NTM database is currently the most comprehensive NTMs database providing NTMs of 85 countries affecting imports (and exports) that are in force as of the data collection year (between 2012 and 2017, depending on the country[7]). It contains a broad range of NTMs, including measures that clearly define trade objectives, as well as regulatory and technical instruments aimed at consumer health and the environment protection by improving production processes and/or product quality. For each NTM, the UNCTAD database provides information on the measure type coded according to the UNCTD-Multi-Agency Support Team (MAST) Classification of Non-Tariff Measures 2012 (UNCTAD, 2015). Specifically, the UNCTAD classifies NTMs into 16 chapters (A–P) based on the purpose of the measure, each of which is further differentiated into 11 subgroups. Most NTMs are available by imposing country and product category as per the 6-digit Harmonized System (HS) classification. Nevertheless, there are a few exceptions where NTMs are defined at a more aggregated level (e.g., HS2 or HS4) or a more detailed level (e.g. HS8 or HS10). For the former case, I assume NTMs that defined at HS2 or HS4 levels will affect all HS6 products that belong to the aggregated HS levels. As for the latter case, I aggregate them at the HS6 digit level. With very few exceptions, all tariff lines within a given HS6 product are covered by the NTMs, indicating that this kind of aggregation procedure is not biased towards our analysis. Lastly, in addition to bilateral NTMs that affect specific countries, I also consider unilateral NTMs (e.g., NTMs imposed by destination countries on all exporters) by applying them to all imported products.

As depicted above, the estimation will focus on the technical measures (TMs). Based on the UNCATD's classification, TMs are classified under chapters A–C[8] (UNCTAD, 2019). Specifically, Chapter A deals with sanitary and phytosanitary measures (SPS). SPS are measures to ensure food safety, and to prevent the dissemination of disease or pests. Chapter A also covers all conformity-assessment measures related to food safety, such as certification, testing and inspection, and quarantine. Chapter B collects technical barriers to trade (TBT). It refers to measures such as labeling, standards on technical specifications and quality requirements, and other measures protecting the environment. In the case of SPS, chapter B also includes all conformity-assessment measures related to technical requirements, such as certification, testing, and inspection. Lastly, Chapter C covers the measures related to pre-shipment inspections and other customs formalities. Typically, SPSs and TBTs are the most prominent categories, accounting for about 70% of world's total NTMs.

Table 1 provides a detailed classification of NTMs and the distribution of China's NTMs in force as per the collection year. It can be observed that although most NTMs are designed to affect the export, more than 90% of the remaining import NTMs consist of TMs (among which, SPS and TBT account for the largest proportion, accounting for 43% and 52% respectively), corresponding with the world trend. Table 2 shows the distribution of China's NTMs since its inception. More than 80% of China's NTMs were implemented before 2008, which also explains the reason for using NTM data starting from 2008. Typically, the starting year of regulations in the UNCTAD's dataset is defined as the year of the latest legal amendment of the legislation in each country, which means that in some countries any amendment in an associated legislation updates the date of amendment for the legal document that specifies the details of implementing a

[7] For China, the data were collected in 2016. Regarding other countries, the year of data collection is 2016 for 38 (45%) out of 85 countries, followed by the year 2017 for 28 (33%) countries.

[8] To count the number of TMs, I treat the aggregated NTM codes, such as A50, as representing regulations different from the relevant measures within the same one-digit numerical category. A TM can be coded at a higher level even though more disaggregated codes exist, if a relevant legal document does not provide enough information to assign the measure to a disaggregated level, though such cases are rare. Another related case is where the 'not elsewhere specified (n.e.s.)' code is used if a requirement is precisely defined in a legal document but does not match any of the existing codes. See UNCTAD (2014) for more details on when the higher-level and n.e.s. codes can be used in constructing the original database.

particular regulation without substantial change in the content of the regulation itself. A substantial portion of seemingly new regulations do not necessarily include regulations that were introduced in each reported year[9]. Table 2 shows that China's NTMs released after 2008 do not suffer from this problem. While using the NTM panel data, one still needs to bear the mild censored data problem because one cannot deny the possibility that there were a few NTMs that expired before the year of data collection. Nevertheless, the consistent rule of updating NTMs in China enables me to expand the original cross-sectional dataset. Furthermore, due to the inconsistent definition of NTM updates across countries, one can only make use of the import data from Chinese firms because foreign firms exporting to China will meet the NTMs released by China and hence follow the consistent definition of update.

Table 1. Classification of China's NTMs

Category	Classification	Chapter	Description	Freq.	Prop. (%)
Imports	Technical measures	A	Sanitary and phytosanitary measures	55,709	8.68%
		B	Technical barriers to trade	63,649	9.92%
		C	Pre-shipment inspection and other formalities	2,112	0.33%
	Non technical measures	D	Contingent trade-protective measures	0	0%
		E	Prohibitions and quantity-control measures other than SPS or TBT	621	0.10%
		F	Price-control measures	1,887	0.29%
		G	Finance measures	21	0.003%
		H	Measures affecting competition	233	0.04%
		I	Trade-related investment measures	338	0.05%
		J	Distribution restrictions	4	0.001%
		K	Restrictions on post-sales services	0	0%
		L	Subsidies	0	0%
		M	Government procurement restrictions	0	0%
		N	Intellectual property	342	0.05%
		O	Rules of origin	1,247	0.19%
Exports		P	Export-related measures	515,612	80.34%

Source: Author's calculation based on the UNCTAD TRAINS Database.

Table 2. Start Year of China's NTMs

9 In the case of Japan, for example, whose year of data collection is 2016, 30% of the observations are recoded with the starting year as 2016, that is, recorded as having been implemented since 2016. In the Japanese legal system, a legal act sets a general broad framework, ordinance prescribes the details of regulatory requirements, and decree might reflect the affected products. A similar issue regarding the starting year information is suspected for NTMs reported by other countries such as Korea.

Year	Freq.	Prop.(%)
<2008	100,527	15.66%
2008	465,527	72.54%
2009	3,337	0.52%
2010	2,158	0.34%
2011	21,908	3.41%
2012	1,124	0.18%
2013	9,291	1.45%
2014	19,677	3.07%
2015	9,893	1.54%
2016	8,333	1.30%
Total	641,775	100%

Source: Author's calculation based on the UNCTAD TRAINS Database.

3.3 Chinese Firm-level Data on Trade

Chinese firms' import data is provided by the Chinese Customs Trade Statistics (CCTS) managed by the General Administration of Customs of China. The CCTS database covers trade records of all merchandise transactions passing through Chinese customs from 2000–2013, including firm identification (name, address, ownership), HS product code, the value of imports (also exports), the quantity of goods, customs regimes, means of transportation, customs code, origin, and destination country. The import values are reported as free-on-board (*fob*) values in US dollars. Being consistent with the NTM dataset, I partly utilize the import data after 2008 in order to deal with the potential censored information on the updating of China's NTMs as descried in Section 3.2. Consequently, my analysis relies on the combined dataset for the period of 2008–2013. As the data is provided in a monthly format, I aggregate it to an annual format.

As for the sample size, each HS6 heading has about 3,000,000 potential importers and 200 origin countries in a period of 5 years. To handle manageable data sets, I first exclude the service industries in the estimation (98 and 99 in the HS classification). Next, I only include firms that import a product from a particular market for at least two years in order to reduce any bias caused by occasional importers. Finally, I aggregate the information on exported products – originally provided at HS8 – into HS6 classification, which is also used by the UNCTAD to record NTMs. The comprehensive firm-level panel data on imports enables me to answer if and how technical NTMs affect the quantity of trade, the dynamics of participating in global markets, and the importer's price setting. As indicated below, I will further control for firm characteristics when investigating the effect of technical NTMs.

Table 3 underlines the importance of controlling for a firm's GVC positioning when examining the effect of NTMs on margins of trade. As the results show, the Kolmogorov-Smirnov test strictly rejects the null hypothesis, which means that the two GVC positioning distributions are statistically different from each other. This result indicates that the distribution of firm's GVC positioning is less dispersed with a higher mean for firm's import quantity in markets with NTM restrictions than in markets without such restrictions.

Table 3. Kolmogorov-Smirnov Test by NTM Presence

	Group	Obs.	Mean	Std. Dev.	Min	Max	p-value
Downi(ln)	NTM=0	1,610,821	1.245	0.065	0.700	1.357	0.00***
	NTM≥1	5,155,894	1.260	0.077	0.700	1.357	

3.4 Estimation Strategies

The research question in this study is whether the TMs impose heterogeneous effects on a firm's trade performance. Regarding margins of trade, the introduction of TMs is likely to impose both additional fixed costs (e.g., firms are required production process changes) and variable cost (e.g., firms are required input and product are upgraded) on the economy. According to the Melitz (2003) model of heterogeneous firm, the fixed cost raised by a regulatory standard is expected to mainly affect the extensive margin of trade, whereas the variable cost is expected to affect both the extensive and intensive margins of trade. Therefore, TMs are expected to make firm exit the market so that negatively affect Chinese firms' imports on the extensive margin of trade. In terms of the intensive margin, the effect of new TMs is ambiguous. Higher variable costs reduce the trade quantity, while higher fixed import costs may have a positive impact on the trade quantity through an indirect effect on the price index of the importing country by fostering exit from a destination market so that reduce competition. Furthermore, GVC is another unneglectable factor. The distance from the origin of the TMs to the exporting country increases the difficulty of foreseeing the net effect of TMs. That is, the effect of NTMs on firms would also vary depending on firms' positioning in the GVC. However, in the existing studies, little is known about the effect of NTMs on import participation by the firm's role in the GVC as the compliance costs are not directly borne by the domestic importers. I expect the negative effect of TMs on firms' trade margins to mitigate as firm's GVC downstreamness increases, because firms with more GVC backward linkage tend to be less responsive to trade shocks.

The impact of TMs on import price is less predictable. Intuitively, the introduction of additional TMs will increase the import price due to the increased fixed and variable compliance costs. Part of the compliance costs then may be passed on to importing firms and finally to the consumers in the destination markets, while the consumers would be willing to pay a "quality premium" for products that meet specifications for quality and safety covered TMs (Curzi et al., 2020). Moreover, the firm-heterogeneity trade model suggests that TM measures may lead to a redistribution of market shares among firms which enables surviving firms to upgrade the product quality. Regarding the potential heterogenous impact on prices, though with few existing studies, firms with larger GVC downstreamness would less respond to tougher TMs because their products are likely to have passed similar type of technical requirements imposed by the upstream markets compared to the products imported by firms with smaller downstreamness.

Against the above background, this study aims to investigate Chinese importer's trade performance in terms of the quantity of product, trade participation, and price-setting as a function of NTM and firm characteristics, especially focusing on the firm's GVC positioning. The empirical framework further controls for bilateral tariff levels and a set of fixed effects for several unobservable factors affecting trade. Specifically, the estimation strategy is given as follows[10]:

$$y_{f,p,j,t} = \alpha + \beta_1 \ln CountNTM_{p,j,t} + \beta_2 \ln Down_{f,t-1} + \beta_3 \left(\ln CountNTM_{p,j,t} * \ln Down_{f,t-1}\right) + \beta_4 \ln Visibility_{f,HS2,j,t-1} + \beta_5 \ln size_{f,t-1} + \beta_6 \ln Tariff_{p,j,t} + \gamma_f + \gamma_{HS2,j,t} + \varepsilon_{f,p,j,t}, \quad (6)$$

where the subscripts *f*, *p*, *j*, *t* respectively stands for the firm, the HS6-digit product category, country of origin, and the year. In order to investigate the impact of NTM regulations on the margins of trade and the unit price, $y_{f,p,j,t}$ consists of the following three variables:

(1) (log of) the firm's import value (which is directly provided by the CCTS dataset), which is the measure of intensive margin.
(2) the probability of firm *f* importing from a certain product-origin market combination, which is the measure of extensive margin. The counterfactual scenario is that the firm does not import from the same product-origin combination. This discrete choice model can be defined as a

[10] Eq. (6) is estimated via the ordinary least square (OLS) rather than the non-linear binary choice models such as the logit models to avoid the incidental parameter problem due to the sizeable set of fixed effects included in all regressions. Another trivial advantage of the OLS models is that they provide the direct estimation of the sample average marginal effect.

latent variable $y^{*}_{i,p,j,t}$ that determines whether positive import flow is observed. The equation can then be written as:

$$\text{Prob}(y_{f,p,j,t}) = \begin{cases} 1 \;\; if \;\; y^{*}_{f,p,j,t} > 0, \\ 0 \;\; if \;\; y^{*}_{f,p,j,t} \leq 0. \end{cases} \quad (7)$$

(3) (log of) the price of products paid by the importing firms. It is notable that as the CCTS dataset does not directly provide information on a firm's product prices, the dependent variable is proxied by the unit import value (calculated as the import value divided by the import quantity). Typically, a higher price does not necessarily indicate higher product quality because it can alternatively mean a higher horizontal product differentiation, lower productivity, or a higher unit cost as a result of the TMs. Here, I assume the perfect information situation between Chinese importers and foreign suppliers concerning product quality, which is in line with earlier studies (e.g. Kugler & Verhoogen, 2012; Baldwin & Harrigan, 2011) that explored quality sorting in international trade to explain the same.

As for the control variables, $CountNTM_{p,j,t}$, the key regressor of interest is defined as the number of NTM measures imposed by China on a given HS6 product *p* imported from country *j* in year *t*. As the UNCTAD database does not explicitly provide the information on the restrictiveness of each NTM, one can assume the number of NTMs as a proxy. Typically, it may be more costly and therefore more difficult for firms to enter a foreign market with substantial number of TMs. It is worth noting that China's NTMs are imposed on the foreign suppliers who export their products to Chinese market. Therefore, it is the exporters instead of domestic importers that need to bear the potential compliance costs raised by China's TMs. Most of the existing studies focused on how the impact of NTMs imposes a productivity threshold for export firms. As for this study, although the specification cannot directly control for the productivity of the export firms from foreign countries, it is, however, not the main question under investigation. The effect of NTMs would differ across firms with heterogeneous ability to comply with the NTMs whereas I include Chinese firm's productivity in the specification as discussed below. Nonetheless, the unobservable characteristics of foreign suppliers that would affect the import performance of Chinese firms are substantially controlled by the fixed effect that is discussed below. $Down_{f,t-1}$ is another key variable which implies the (lagged) GVC downstreamness of firm *f* following the definition introduced in Section 3.1. The interaction between the number of NTMs and GVC downstreamness, that is $lnCountNTM_{pjt} * \ln Down_{f,t-1}$, is responsible for capturing the potential heterogeneous effect of NTMs on a firm's trade performance. Typically, I suppose that firms that cannot overcome the additional compliance cost of an NTM will be compelled to stop importing, therefore a negative effect of NTMs on firms' import probability is expected. Finally, though not necessary, I still conduct a robustness check using cluster standard errors, given that this interaction term varies at the firm-HS6-origin-year level. The results are shown in Table A3 and support the robustness of the consequences explained below.

I also include a list of auxiliary firm controls in the specification. $size_{f,t-1}$ is the (lagged) firm-specific characteristic that captures heterogeneous importer performance across firms related to firm productivity (since the productivity is unobserved in my dataset, I proxy it by the firm size). Since the CCTS database does not contains comprehensive information on Chinese importers' balance sheets, the firms size variables are measured by firm's total imports rather than total sales. The empirical literature has extensively shown that import values are a good proxy for the firm size as one can expect that big importers should usually have larger scale and are more efficient than non-importers (see e.g. Halpern et al. (2005)). In reference to Fontagné et al. (2015), large and visible firms may be targeted by policymakers, and NTM measures can be protectionist. I account for this by introducing a variable controlling for the visibility of the firm: $Visibility_{f,HS2,j,t-1}$ measures lagged firm's importance, in terms of its imports, in a certain sector, and the market of origin. This is calculated as (the log of one plus) the share of imports of a firm in a certain market and HS2 sector over total Chinese imports in the same market and sector. Furthermore, as existing literature argues that NTMs may be a substitute or complement policy of tariff with no consensus, it is needed to control for applied tariffs at the product-origin-year level $Tariff_{p,j,t}$. The tariff data is also available at the UNCTAD TRAINS database. In the analysis, tariffs are measured in percentages and transformed into the price equivalent form: $\ln(Tariff_{p,j,t} + 1)$. Typically, variables of the firm size, firm visibility, and the firm's GVC positioning, are lagged by one year in order to reduce the potential reverse causality from the trade performance. Nonetheless, I conduct the robustness check in Section 4.4 with the one-year lagged number of NTMs, $\ln CountNTM_{p,j,t-1}$, to address the same concern on my key variable. Table 4 provides some descriptive statistics of the variables employed in the regressions.

Finally, γ_f and $\gamma_{HS2,j,t}$ are two sets of fixed effects aimed at controlling for the unobservable factors. The first one is a set of firm's fixed effects to control for the time-invariant firm characteristics. The second set is the HS2-origin-year fixed effects which controls for country-time-HS2- level varying factors. $\varepsilon_{f,p,j,t}$ is the independent and identically distributed error term.

During estimating Eq. (5), the endogeneity problem remains a crucial concern. The endogeneity would result from either omitted variables or reverse causality. The omitted variable can be addressed by the firm and HS2-origin-year fixed effects, which is my preferred set of fixed effects because of its ability to capture unobservable characteristics affecting firms' import behavior. The reverse causality problem, which means that the firm's trade of margins would affect the number of NTMs imposed on an HS6 level product, may arise if the Chinese government introduces any NTM to macro-control large Chinese importers that have high market power in order to avoid the possibility of a warped economy.

There is existing literature such as Fontagné et al. (2015), Disdier et al. (2018), Curzi et al. (2020) who investigated the NTMs imposed by foreign countries on domestic firm's export. Compared to these studies, the NTMs imposed by the local government on domestic firms are more likely to be endogenous because it is easier for the local policymakers to observe the trading behavior of domestic firms. However, as the NTMs will equally impose restrictions on domestic importers and foreign suppliers, there is less incentive for policymakers to introduce strict NTMs in response to the domestic firm's trade performance, rather as the foreign policymakers do after observing the behavior of domestic firms. That is, the reverse causality problem is to some extent alleviated. Nevertheless, I conduct a bundle of robustness checks to address the endogeneity problem between the introduction of NTMs and the margins of trade.

Table 4. Summary Statistics

	Obs.	Mean	Std. Dev.	Min	Max
CountNTM (ln)	6,874,462	1.274	1.000	0	4.489
Downi (ln)	6,766,715	1.257	0.075	0.700	1.357
Visibility (ln)	6,874,462	0.004	0.027	1.E-11	0.693
Firm size (ln)	6,874,462	16.142	2.542	0	25.388
ln(Tariff+1)	6,549,323	0.067	0.047	0	0.811
Intensive	6,874,462	10.750	2.804	0.693	24.731
Extensive	16,099,590	0.427	0.495	0	1

4. Empirical Result

4.1 Impact on Intensive Margin

The estimation results for the effect of technical NTM measures on the intensive margin of trade are shown in Table 5. Column 1 gives the result for the simplest model which only controls for the tariffs and the fixed effects. A positive and significant coefficient indicates that a 1% increase in the number of TM measures for a certain HS6 level product increases the trade value of imports by approximately 0.1%. Tariffs have a negative and significant impact on the intensive margin as expected, supporting the assertion that tariffs act as a substitute for NTMs. One would notice that the magnitude of the coefficients on tariffs is much larger than that of coefficients on TM regulations[11], while a similar study conducted by Fontagné et al. (2015) obtained a larger magnitude of coefficients on NTMs than that of coefficients on tariffs. The difference is that earlier work looked at the NTMs imposed by destination countries based on their vested interests and is therefore possibly harmful to foreign firms, whereas this paper focuses on the NTMs subjected to its import to represent domestic interest. For comparison, I test the same specification using the cross-sectional dataset of Chinese firm's exports and the effects of tariff revealed are similar to the NTM regulation variable[12]. The results are available on request. Although there is a concern that the tariff rates the Chinese government imposes on foreign countries might be endogenous, I do not focus on instrumenting for the tariffs since it is not my principal measure of trade policy. A more crucial concern is that the TMs might be implemented by taking the domestic firm's interest into consideration, which thus indicates that China's TMs would be the possibly endogenous policies. I will deal with this issue in the robustness checks including via instrumental variable estimations.

In Column 2, the firm-level GVC downstreamness index is controlled (which explains why the number of observations decreases compared to Column 1). The coefficient of TMs remains positive and significant. The negative sign of the GVC index shows that firms located more downstream regarding its input tend to have lower intensive margins, meaning that the more backward linkage along the GVC a firm has, the lesser the quantity it imports from the specific market. One possible reason is that firms with more backward linkage have relatively more choice of suppliers to purchase their products from in the global market. Another possible explanation is given by Miller and Temurshoev (2017), in which they claimed that China's intra-country intermediate input, especially in manufacturing sectors, is the most important factor in locating China far away from the starting point of the global input demand chains, indicating that Chinese manufacturing firms purchase a considerable proportion of their input from the domestic market. For a representative, a Chinese trading firm that purchases its input and provides its output to both the domestic and the global market. Keeping the quantity of input unchanged, it can be inferred that the more downstream the firm is located in the GVC, the higher the proportion of intermediate inputs purchased from the domestic market in order to import lesser quantity from the global market.

Column 3 additionally controls for the firm-level characteristics including the (one-year lag of) firm size and the firm's visibility. Again, a positive effect of TMs is observed. The coefficient on firm size is positive and significant as expected, which indicates that larger importers purchase a larger quantity of product from the global input market. This finding on the positive relationship between the quantity demanded and the importer's scale complements Fontagné et al. (2015) in which they found a positive relationship between firm size and the trade quantity among French exporters. The visibility variable, which reflects the importance of the firm within the HS2-level

[11] A more recent study by Curzi et al. (2020) conducted a similar analysis of how NTMs affect Peruvian firm's agri-food export performance. Their results showed that tariffs have a substantially higher impact on firm's margins of trade than NTMs. Given that Curzi et al. (2020) also relied on the firm-level data on the developing country and they focused on the most stringent food standards, the results of this study reveal reasonable.

[12] Due to the problem of inconsistent definition of NTM update across countries as described in Section 3.2, I cannot expand the cross-sectional NTM database affecting Chinese firms into a panel so that this estimation has to rely on a cross-sectional dataset.

market, is also reasonably positive. Other things being equal, firms with higher visibility within the origin country and the HS2 level product need to import larger quantities.

In the next two columns, I reexamine the specifications in Columns 2–3 by additionally controlling the interaction term between the number of TMs and the GVC downstreamness index in order to investigate the heterogeneous impact across firms. With the effect of the GVC downstreamness index, the firm size, visibility, as well as the tariffs remain unchanged, and the key variables related to TM regulations provide new insights for us. The signs of the two key variables are opposite: negative coefficients on the number of TMs and positive coefficients on the interaction term, meaning that while the overall effect of TM measures on the import quantity is negative, the effect is alleviated for firms with larger GVC downstreamness. Importantly, there is a threshold of the negative impact where the positive impact of the interaction term can cancel the negative impact of overall TM regulations so that firms with larger downstreamness that surpass the threshold will finally receive a positive impact on their intensive margins. Given the coefficient of the TM regulations equals -0.8, of the interaction term equals 0.7, and the mean value of $lnDown_{f,t}$ equals 1.25, one can conclude that the effect for firms with above-median GVC downstreamness tends to be positive. This result shows that TMs have a heterogeneous impact on importing firms by their GVC positioning. Particularly, when a firm purchases the input mainly from industries that rely largely on value-added from primary factors of production in the global input market, which is embodied as low GVC downstreamness, the TMs will act as an obstacle that imposes additional compliance costs which decreases the number of imports. In contrast, when a firm purchases inputs from industries that use intermediate inputs intensively (which surpasses the threshold), the products imported by Chinese firms would have passed through various types of technical requirements of the upstream countries and hence is able to meet China's TM requirements at a lower cost. Consequently, the NTMs tend to serve as a lubricant for the surviving firms by imposing the adjustment costs to its potential rivals equally and thus discouraging them from entering the import market.

Table 5. Effect of NTMs on Intensive Margin

	(1)	(2)	(3)	(4)	(5)
	Intensive Margin				
CountAtoC	0.111***	0.102***	0.101***	-0.766***	-0.830***
	(0.00176)	(0.00253)	(0.00251)	(0.0317)	(0.0312)
CountAtoC*Down				0.697***	0.748***
				(0.0254)	(0.0251)
Down		-0.770***	-0.624***	-1.781***	-1.708***
		(0.0800)	(0.0794)	(0.0884)	(0.0877)
Visibility			13.71***		13.74***
			(0.0998)		(0.0999)
Firm size			0.0581***		0.0581***
			(0.00297)		(0.00297)
Tariff	-3.786***	-4.094***	-4.068***	-4.059***	-4.031***
	(0.0355)	(0.0506)	(0.0503)	(0.0507)	(0.0504)
Firm FE	Yes	Yes	Yes	Yes	Yes
HS2-year-destination FE	Yes	Yes	Yes	Yes	Yes
Observations	6,543,321	3,197,742	3,197,742	3,197,742	3,197,742
R-squared	0.299	0.305	0.312	0.305	0.313

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

4.2 Impact on Extensive Margin

Table 6 corresponds to the effect of TM regulations on the extensive margin of trade. Through Columns 1–3, I examine how the TMs affect the possibility of import by simply using the number of TMs imposed on the origin-HS6 level product. Importantly, the negative and significant coefficients of TMs on the extensive margin in all specifications indicate that a one percent increase in the number of the TMs decreases the probability of foreign suppliers entering the Chinese markets by 0.0025 percent. As for the control variables, tariffs have a reasonably negative and significant effect on the extensive margin. Continuing from the intensive margin, tariffs which can be interpreted as the variable trade cost simply hinder firms from connecting to the global market. Firm's size and visibility are positively related to the dependent variable indicating that small-scale firms are not able to participate in the import market. Though an exporting firm does not necessarily import as well, this result is in line with the heterogeneous-firm trade theory of Melitz (2003) suggesting that the effect of an NTM on trade performance may depend on the size of the firm.

In Column 4–5, the interaction term between the number of TMs and the firm's downstreamness is employed to examine the heterogeneous effect on the participation in the import market. Although the overall negative impact of TMs on imports is theoretically reasonable, there is no analysis on how TMs affect imports by the firm's GVC positioning. At first glance, the results are the same as the intensive margin analysis: the negative coefficient of the number of TMs, the positive coefficient of the interaction term between the TMs, and the firm's GVC downstreamness. However, taking a deeper look at the magnitudes, given the maximum value of $lnDown_{f,t}$ equals 1.36, one can confirm that the opposite effect of the interaction term is not large enough to cancel the negative impact of TMs on the probability of import for firms with average downstreamness, which thus indicates that TMs prevent a firm with average downstreamness from importing, while the negative effect is attenuated in firms with large downstreamness in the global input market. The negative impact on the probability of import is that while the compliance cost raised by TMs generally hinders a firm from getting access to foreign suppliers, products purchased from industries with larger GVC downstreamness would have been subjected to similar technical requirements before arriving in China and which conform to China's additional requirements. As for the other control variables, including the firm size, visibility, GVC positioning as well as tariffs, have no qualitative change compared to the first three columns.

In combination with the results for the intensive margin, one can conclude that unlike tariffs, that are a pure barrier to trade, TMs play different roles depending on the firm's positioning in the GVC. Essentially, TMs impose technical requirements on products equally on firms entering the Chinese market, while the compliance cost of the technical requirements is not equally distributed across firms. For firms with a low downstreamness in the global input market, resulting from purchasing a substantial amount of product from upstream industries, TMs impose either the fixed entry costs or variable costs and is therefore harmful to both market entry (extensive margin) and trade quantity (intensive margin). However, when a proportional amount of a firm's import comes from industries with large downstreamness, the decreased competition helps the firm increase the quantity of imports. In other words, TMs generate a threshold of downstreamness, below which TMs act as an obstacle and above which TMs act as a stimulant to trade. This conclusion is in line with a series of earlier works (e.g. Disdier et al., 2018, Crivelli & Groeschl, 2016) which found that the role of NTMs in trade is ambiguous regarding different firm's characteristics. The contribution of this paper is that it further sheds light on the heterogeneity of TMs depending on the GVC positionings.

Table 6. Effect of NTMs on Extensive Margin

	(1)	(2)	(3)	(4)	(5)
			Extensive Margin		
CountAtoC	-0.00243***	-0.00270***	-0.00271***	-0.00520***	-0.00332***
	(0.000191)	(0.000208)	(0.000207)	(0.000344)	(0.000343)
CountAtoC*Down				0.00229***	0.000561**
				(0.000269)	(0.000269)
Down		0.213***	-0.106***	0.210***	-0.106***
		(0.000387)	(0.00129)	(0.000507)	(0.00132)
Visibility			0.704***		0.704***
			(0.00844)		(0.00844)
Firm size			0.0285***		0.0285***
			(0.000109)		(0.000109)
Tariff	-0.147***	-0.127***	-0.125***	-0.127***	-0.125***
	(0.00374)	(0.00412)	(0.00411)	(0.00412)	(0.00411)
Firm FE	Yes	Yes	Yes	Yes	Yes
HS2-year-destination FE	Yes	Yes	Yes	Yes	Yes
Observations	15,259,892	12,734,820	12,734,820	12,734,820	12,734,820
R-squared	0.268	0.272	0.276	0.272	0.276

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

4.3 Impact on import price

The impact of TMs on the import price appears in Table 7. As discussed in Section 3.4, the dependent variable is proxied by the unit import value. Further, a higher price has no evident relationship with higher product quality but rather results from higher horizontal product differentiation, lower productivity, or higher unit cost.

Consistent with the intensive and extensive margin analysis, I first examine how the TMs affect the prices of imported products by simply including the number of TMs through Columns 1–3. Positive and significant effects on the dependent variable are found, which are in line with the prediction. Theoretically, facing the requirement of TMs forces firms to scrutinize the trade-off between fixed and variable costs and importing opportunities based on their ability to comply. This process leads to a redistribution of market shares among firms by weeding out those with inferior competitiveness from the import market. The surviving Chinese importers would then be able to distribute part of the cost of overcoming the threshold created by TMs to domestic consumers through product upgrade and higher product prices. The tariffs, as a pure barrier to trade, are also positively related to import price, indicating that a part of the importing cost is passed on to importers and subsequently to consumers by the surviving firms. This is theoretically reasonable as tariffs are considered to result in the loss of consumer surplus by compelling consumers to pay higher prices. From this mean, TMs play the same role as tariffs in the international market with smaller magnitudes.

Columns 4–5 capture the heterogeneous effect of TMs across Chinese firms by employing the interaction term between the number of TMs and the GVC downstreamness. While the overall positive impact of TMs on prices is found, it is difficult to predict the relative impact of importer's GVC downstreamness. On one hand, importers with more backward linkage along the GVC (represented by a larger downstreamness) deal with products supplied from upstream firms that also deal with intermediate inputs subjected to various types of technical requirements of the world may adapt to China's requirements at a lower cost. On the other hand, after the trading threshold of GVC downstreamness discourages competitors, the surviving importers with the largest GVC backward linkage may have to face higher input prices by their suppliers as a result of the lowered elasticity of demand. The estimation results support the former hypothesis. While the positive signs of TMs remain unchanged, the negative coefficients of the interaction term show that firms located more downstream in the global input market have a lower elasticity of demand stemming from less market competition. In addition, the magnitude of the interaction term is not large enough to cancel the overall positive effect on the prices, making the overall positive effect of TMs consistent through the specifications.

Table 7. Effect of NTMs on Unit Value

	(1)	(2)	(3)	(4)	(5)
	Unit Value				
CountAtoC	0.356***	0.368***	0.368***	0.675***	0.676***
	(0.00147)	(0.00207)	(0.00207)	(0.0240)	(0.0240)
CountAtoC*Down				-0.247***	-0.247***
				(0.0196)	(0.0196)
Down		0.644***	0.668***	1.003***	1.028***
		(0.0653)	(0.0653)	(0.0698)	(0.0699)
Visibility			-0.121**		-0.130**
			(0.0512)		(0.0512)
Firm size			0.0238***		0.0238***
			(0.00249)		(0.00249)
Tariff	2.910***	2.964***	2.963***	2.951***	2.951***
	(0.0329)	(0.0476)	(0.0476)	(0.0477)	(0.0477)
Firm FE	Yes	Yes	Yes	Yes	Yes
HS2-year-destination FE	Yes	Yes	Yes	Yes	Yes
Observations	6,272,058	3,074,435	3,074,435	3,074,435	3,074,435
R-squared	0.537	0.535	0.535	0.535	0.535

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

4.4 Robustness Checks

In this section, I conduct a series of sensitivity tests to address the concerns regarding the reliability of my results. As discussed above, the first issue is the potential endogeneity bias raised by omitted variables or reverse causality problem. While the omitted variable concern is drastically decreased by the set of fixed effects, the reverse causality problem remains, especially in the case where TMs affecting Chinese firms are implemented by the domestic government and is, therefore, more likely to be designed in response to the trade performance of Chinese firms. Therefore, I first reexamine Eq. (5) by using the lagged key variables: the number of TMs ($\ln CountNTM_{p,j,t-1}$) and the interaction term between TMs and GVC downstreamness $\left(\ln CountNTM_{p,j,t-1} * \ln Down_{f,t-1}\right)$. The basic idea assumes that the number of TMs one year before the import is likely to be exogenous. Recall that in the baseline estimations, all the explanatory variables related to firm characteristics are lagged. In other words, the first robustness check regresses the three dependent variables on the explanatory variables in Eq. (5) with a one-year lag. The results shown in Table 8 comprehensively prove that my results are robust. The increase in the number of TMs increases the intensive margin because the opposite signs of the interaction term verify the heterogeneous effect on firms (Columns 1–5). Further, TMs decrease the extensive margin of trade. The heterogeneous impact of a firm's GVC downstreamness is also confirmed by the interaction terms (Columns 6–10). Finally, Columns 11–15 suggest that the product prices are raised by TMs, with the impact being attenuated for importers located more downstream in the GVC.

I alternatively address the endogeneity bias using the instrumental variable 2SLS approach. With reference to Fontagné et al. (2015), I calculate the total number of NTMs raised in the HS2 sector to which the HS6 level product belongs (excluding the NTMs raised at the HS6 level itself) and employ it as the instrument (denoted by $\ln CountNTMHS2_{p,j,t}$). The assumption is that when there is an NTM introduced for an HS6 level product, a similar NTM is also likely to be raised for products belonging to the same HS2 sector. The results appear in Table 9. Again, there is no qualitative change observed, supporting the robustness of the previous results[13]. The impact of NTM on a firm's import quantity is positive and significant, with the effect being expanded for firms located more downstream in the GVC (Columns 1–5). As for the probability of import, the results confirm that the overall negative impact is alleviated for firms with larger GVC downstreamness (Columns 6–10). Regarding the unit price, the increase in import prices due to the pressure of NTM compliance is mitigated for firms with a deeper connection to the global input market (Columns 11–15).

Lastly, there may be a concern of reverse causality due to a firm's trade behavior on its GVC downstreamness. Indeed, as the firm-level GVC downstreamness index is defined as the value-weighted average of the industry-level, one cannot deny the possibility of a specialized firm that imports limited products from specific suppliers constantly, making its GVC positioning index highly dependent on certain imports. To deal with this problem, I use the lagged industry-level GVC downstreamness index following the definition of Eq. (4), that is $Down_{i,t-1}$, as well as the interaction term, to run the specification in Eq. (5). Indeed, the industry-level downstreamness is less dependent on a particular firm's import performance as it is also determined by the linkages in a full production network that involves the whole global market. Specifically, industry i is determined as the ISIC sector that the HS6 level imported product belongs to. Thus, one can alternatively interpret the interaction term $\ln CountNTM_{p,j,t} * \ln Down_{i,t-1}$ as the heterogeneous impact on the dependent variable by the product's downstreamness in the GVC. The results are given in Table 10. Columns 1–5 show that the overall positive impact along with the negative and heterogeneous impact of TMs by the GVC downstreamness on the import quantity is again detected, meaning that the analysis on the intensive margin is robust. As for the extensive margin, TMs are negatively associated with the possibility of import and the effect diminishes by the industry's GVC downstreamness (Columns 6–10). Finally, Columns 11–15 support the results that importers need to pay a higher price for products that have additional TMs imposed on them, while the price is lower to firms with larger downstreamness in the global input market.

[13] The results from the first stage of the 2SLS estimation are available on request.

Table 8. Robustness Checks: Lagged Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Intensive Margin					Extensive Margin					Unit Value				
CountAtoC	0.118***	0.106***	0.104***	-0.815***	-0.877***	-0.00244***	-0.00243***	-0.00247***	-0.00406***	-0.00219***	0.356***	0.375***	0.375***	0.759***	0.759***
	(0.00184)	(0.00256)	(0.00255)	(0.0316)	(0.0312)	(0.000214)	(0.000212)	(0.000211)	(0.000349)	(0.000349)	(0.00153)	(0.00210)	(0.00210)	(0.0241)	(0.0241)
CountAtoC*Down				0.740***	0.789***				0.00149***	-0.000257				-0.309***	-0.309***
				(0.0254)	(0.0250)				(0.000272)	(0.000272)				(0.0196)	(0.0196)
Down		-0.772***	-0.626***	-1.817***	-1.740***		0.213***	-0.106***	0.211***	-0.106***		0.635***	0.659***	1.074***	1.098***
		(0.0800)	(0.0794)	(0.0880)	(0.0873)		(0.000387)	(0.00129)	(0.000504)	(0.00132)		(0.0652)	(0.0653)	(0.0695)	(0.0695)
Visibility			13.71***		13.74***			0.704***		0.704***			-0.124**		-0.134***
			(0.0998)		(0.0999)			(0.00844)		(0.00844)			(0.0512)		(0.0513)
Firm size			0.0580***		0.0580***			0.0285***		0.0285***			0.0235***		0.0234***
			(0.00297)		(0.00297)			(0.000109)		(0.000109)			(0.00249)		(0.00249)
Tariff	-3.712***	-4.098***	-4.073***	-4.066***	-4.038***	-0.127***	-0.127***	-0.125***	-0.127***	-0.125***	2.864***	2.950***	2.949***	2.937***	2.936***
	(0.0367)	(0.0506)	(0.0503)	(0.0507)	(0.0504)	(0.00416)	(0.00412)	(0.00411)	(0.00412)	(0.00411)	(0.0340)	(0.0476)	(0.0476)	(0.0476)	(0.0476)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HS2-year-destination FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,039,901	3,197,742	3,197,742	3,197,742	3,197,742	12,734,820	12,734,820	12,734,820	12,734,820	12,734,820	5,785,088	3,074,435	3,074,435	3,074,435	3,074,435
R-squared	0.304	0.305	0.312	0.305	0.313	0.257	0.272	0.276	0.272	0.276	0.539	0.535	0.535	0.535	0.535

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 9. Robustness Checks: Instrument Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Intensive Margin					Extensive Margin					Unit Value				
CountAtoC	0.122***	0.0875***	0.0863***	-5.110***	-4.904***	-0.00372***	-0.00433***	-0.00338***	-0.0192***	-0.00953***	0.0543***	0.101***	0.101***	6.154***	6.146***
	(0.00374)	(0.00458)	(0.00452)	(0.0793)	(0.0779)	(0.000447)	(0.000489)	(0.000487)	(0.000701)	(0.000699)	(0.00235)	(0.00277)	(0.00277)	(0.0657)	(0.0656)
CountAtoC*Down				4.220***	4.052***				0.0141***	0.00582***				-4.919***	-4.912***
				(0.0643)	(0.0631)				(0.000487)	(0.000486)				(0.0534)	(0.0533)
Down		-0.780***	-0.634***	-6.895***	-6.505***		0.213***	-0.106***	0.196***	-0.112***		0.596***	0.620***	7.754***	7.768***
		(0.0801)	(0.0795)	(0.126)	(0.124)		(0.000387)	(0.00129)	(0.000707)	(0.00140)		(0.0655)	(0.0656)	(0.0993)	(0.0992)
Visibility			13.71***		13.85***			0.704***		0.703***			-0.0983*		-0.260***
			(0.0999)		(0.101)			(0.00844)		(0.00844)			(0.0516)		(0.0536)
Firm size			0.0575***		0.0573***			0.0285***		0.0284***			0.0235***		0.0237***
			(0.00298)		(0.00299)			(0.000109)		(0.000109)			(0.00250)		(0.00253)
Tariff	-3.806***	-4.094***	-4.069***	-3.903***	-3.885***	-0.146***	-0.126***	-0.125***	-0.126***	-0.125***	3.061***	3.097***	3.097***	2.887***	2.886***
	(0.0355)	(0.0507)	(0.0504)	(0.0513)	(0.0509)	(0.00374)	(0.00412)	(0.00412)	(0.00413)	(0.00412)	(0.0329)	(0.0476)	(0.0476)	(0.0481)	(0.0481)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HS2-year-destination FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,522,567	3,192,776	3,192,776	3,192,776	3,192,776	15,259,892	12,734,820	12,734,820	12,734,820	12,734,820	6,251,329	3,069,478	3,069,478	3,069,478	3,069,478
R-squared	0.003	0.003	0.013	-0.003	0.008	0.000	0.019	0.025	0.019	0.025	0.005	0.007	0.007	-0.013	-0.012

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 10. Robustness Checks: Industry Level GVC Downstreamness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Intensive Margin				Extensive Margin				Unit Value			
CountAtoC	0.107***	0.106***	-0.713***	-0.732***	-0.00226***	-0.00236***	-0.00176***	-0.00261***	0.366***	0.366***	1.333***	1.332***
	(0.00253)	(0.00251)	(0.0271)	(0.0269)	(0.000207)	(0.000206)	(0.000240)	(0.000238)	(0.00207)	(0.00207)	(0.0173)	(0.0173)
CountAtoC*Down			0.668***	0.682***			0.00145***	0.00115***			-1.270***	-1.269***
			(0.0221)	(0.0219)			(0.000232)	(0.000230)			(0.0208)	(0.0208)
Down	-2.543***	-2.489***	-3.735***	-3.706***	0.126***	0.100***	0.128***	0.103***	0.869***	0.870***	-1.528***	-1.526***
	(0.0434)	(0.0431)	(0.0595)	(0.0590)	(0.000260)	(0.000265)	(0.000397)	(0.000397)	(0.0369)	(0.0369)	(0.0463)	(0.0463)
Visibility		13.69***		13.70***		0.521***		0.523***		-0.114**		-0.0927*
		(0.0998)		(0.0998)		(0.00816)		(0.00816)		(0.0512)		(0.0510)
Firm size		0.0583***		0.0579***		0.0163***		0.0163***		0.0231***		0.0223***
		(0.00297)		(0.00297)		(3.31e-05)		(3.31e-05)		(0.00248)		(0.00248)
Tariff	-4.305***	-4.275***	-4.310***	-4.280***	-0.0983***	-0.103***	-0.0986***	-0.103***	3.033***	3.033***	3.021***	3.020***
	(0.0506)	(0.0503)	(0.0506)	(0.0503)	(0.00411)	(0.00408)	(0.00411)	(0.00408)	(0.0477)	(0.0477)	(0.0478)	(0.0478)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HS2-year-destination FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,197,742	3,197,742	3,197,742	3,197,742	12,734,820	12,734,820	12,734,820	12,734,820	3,074,435	3,074,435	3,074,435	3,074,435
R-squared	0.306	0.313	0.306	0.313	0.274	0.285	0.274	0.285	0.535	0.535	0.536	0.536

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

5. Concluding Remarks

In the last decades, while increases in import tariffs have been substantially constrained, the fragmentation of production process in the GVC has been a global trend as a result of the technological, institutional, and political developments. Meanwhile, as the increased technical standards and regulations as a substitute policy to the tariff in international trade have induced many trade disputes among countries, it is critical to elucidate how NTMs affect a firm's trade performance, especially how the impact varies across firms playing different roles in the GVC.

By combining the Chinese firm-level customs data over the 2008–2013 period, the world's industry-level input-output tables, and the comprehensive NTM dataset by the UNCTAD, this study has investigated the impact of the technical measures on a firm's intensive and extensive margins of trade and unit price. I measure the stringency of China's TMs by a continuous variable that reflects the number of TMs imposed on particular HS6 products imported from certain countries each year to examine the impact of these TMs on a Chinese firm's imports. Most importantly, the analysis accounts for a differential effect of TMs across firms located at different positioning in the GVC. The results show that instead of being a pure barrier to trade, TMs play different roles basis the importer's positioning in the GVC. While importers with a small downstreamness receive a negative impact on both intensive and extensive margins, TMs benefit firms located more downstream in the global input market at the expense of the market entrants. In other words, TMs generate a threshold of downstreamness, below which TMs act as an obstacle and above which TMs act as a stimulant of trade performance. Further, firms with larger downstreamness are able to alleviate the pressure of rising prices from their suppliers.

The findings of this study have important implications for formulating policies. The results show that restrictive TMs will lead to a concentrated import market consisting of firms with more total backward linkage in the GVC by weeding out firms with less connection within the GVC from the market. The government should be aware of the heterogeneous impact of TMs on firms that may distort competition and raise inequality in wages in the domestic market. Therefore, TMs must complement domestic policies to exploit trade potential. Specifically, policies that focus on the facilitation of trade for firms with less GVC downward connectivity are important for maintaining a sound market environment as responding to technical requirements is more challenging for these firms.

The comprehensive dataset of NTMs enables me to evaluate the stringency of TMs through a multiyear and continuous measurement to better understand the impact of NTMs. However, as discussed in Beghin et al. (2015), the ambiguous effect of NTMs on trade and welfare makes it complex to sort the NTMs that are useful and progressive from those that are inefficient and protectionist. Thus, it is still far away from a full comprehension of the compound role played by TMs on trade, which therefore calls for further micro-level empirical research to arrive at integrated conclusions.

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Appendix

Table A1. Manufacturing Industry Classification of the World Input-Output Tables

Code	Industry	Code	Industry
A01	Crop and animal production, hunting and related service activities	C24	Manufacture of basic metals
A02	Forestry and logging	C25	Manufacture of fabricated metal products, except machinery and equipment
A03	Fishing and aquaculture	C26	Manufacture of computer, electronic and optical products
B	Mining and quarrying	C27	Manufacture of electrical equipment
C10-C12	Manufacture of food products, beverages and tobacco products	C28	Manufacture of machinery and equipment n.e.c.
C13-C15	Manufacture of textiles, wearing apparel and leather products	C29	Manufacture of motor vehicles, trailers and semi-trailers
C16	Manufacture of wood and of products of wood and cork, except furniture	C30	Manufacture of other transport equipment
C17	Manufacture of paper and paper products	C31_C32	Manufacture of furniture; other manufacturing
C18	Printing and reproduction of recorded media	C33	Repair and installation of machinery and equipment
C19	Manufacture of coke and refined petroleum products	D35	Electricity, gas, steam and air conditioning supply
C20	Manufacture of chemicals and chemical products	E36	Water collection, treatment and supply
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery
C22	Manufacture of rubber and plastic products	F	Construction
C23	Manufacture of other non-metallic mineral products	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles

Table A1. Manufacturing Industry Classification of the World Input-Output Tables (Continued)

Code	Industry	Code	Industry
G46	Wholesale trade, except of motor vehicles and motorcycles	K66	Activities auxiliary to financial services and insurance activities
G47	Retail trade, except of motor vehicles and motorcycles	L68	Real estate activities
H49	Land transport and transport via pipelines	M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities
H50	Water transport	M71	Architectural and engineering activities; technical testing and analysis
H51	Air transport	M72	Scientific research and development
H52	Warehousing and support activities for transportation	M73	Advertising and market research
H53	Postal and courier activities	M74_M75	Other professional, scientific and technical activities; veterinary activities
I	Accommodation and food service activities	N	Administrative and support service activities
J58	Publishing activities	O84	Public administration and defence; compulsory social security
J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities	P85	Education
J61	Telecommunications	Q	Human health and social work activities
J62_J63	Computer programming, consultancy and related activities; information service activities	R_S	Other service activities
K64	Financial service activities, except insurance and pension funding	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households
K65	Insurance, reinsurance and pension funding, except compulsory social security	U	Activities of extraterritorial organizations and bodies

Source: World Input-Output Tables.

Table A2. List of Countries of the World Input-Output Tables

ISO Code	Country	ISO Code	Country
AUS	Australia	IRL	Ireland
AUT	Austria	ITA	Italy
BEL	Belgium	JPN	Japan
BGR	Bulgaria	KOR	Korea Rep.
BRA	Brazil	LTU	Lithuania
CAN	Canada	LUX	Luxembourg
CHE	Switzerland	LVA	Latvia
CHN	China	MEX	Mexico
CYP	Cyprus	MLT	Malta
CZE	Czech Rep.	NLD	Netherlands
DEU	Germany	NOR	Norway
DNK	Denmark	POL	Poland
ESP	Spain	PRT	Protugal
EST	Estonnia	ROU	Romania
FIN	Finland	RUS	Russian Federation
FRA	France	SVK	Slovak Rep.
GBR	United Kindom	SVN	Slovenia
GRC	Greece	SWE	Sweden
HRV	Croatia	TUR	Turkey
HUN	Hungary	TWN	Taiwan
IDN	Indonesia	USA	United States
IND	India	ROW	Rest of the World

Source: World Input-Output Database.

Table A3. Robustness Checks using Clustered Error Terms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Intensive Margin					Extensive Margin					Unit Value				
CountAtoC	0.111***	0.102***	0.101***	-0.766***	-0.830***	-0.00243*	-0.00270	-0.00271	-0.00520*	-0.00332	0.356***	0.368***	0.368***	0.675***	0.676***
	(0.0113)	(0.0157)	(0.0157)	(0.145)	(0.142)	(0.00147)	(0.00167)	(0.00166)	(0.00308)	(0.00295)	(0.0213)	(0.0269)	(0.0269)	(0.127)	(0.127)
CountAtoC*Down				0.697***	0.748***				0.00229	0.000561				-0.247**	-0.247**
				(0.122)	(0.120)				(0.00257)	(0.00244)				(0.107)	(0.107)
Down		-0.770***	-0.624***	-1.781***	-1.708***		0.213***	-0.106***	0.210***	-0.106***		0.644***	0.668***	1.003***	1.028***
		(0.238)	(0.232)	(0.293)	(0.288)		(0.00560)	(0.00579)	(0.00511)	(0.00726)		(0.173)	(0.169)	(0.230)	(0.228)
Visibility			13.71***		13.74***			0.704***		0.704***			-0.121		-0.130
			(0.214)		(0.215)			(0.0188)		(0.0188)			(0.0838)		(0.0841)
Firm size			0.0581***		0.0581***			0.0285***		0.0285***			0.0238***		0.0238***
			(0.00884)		(0.00883)			(0.000797)		(0.000789)			(0.00775)		(0.00775)
Tariff	-3.786***	-4.094***	-4.068***	-4.059***	-4.031***	-0.147***	-0.127***	-0.125***	-0.127***	-0.125***	2.910***	2.964***	2.963***	2.951***	2.951***
	(0.247)	(0.295)	(0.295)	(0.299)	(0.298)	(0.0262)	(0.0295)	(0.0294)	(0.0295)	(0.0294)	(0.400)	(0.545)	(0.545)	(0.546)	(0.546)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HS2-year-destination FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,543,321	3,197,742	3,197,742	3,197,742	3,197,742	15,259,892	12,734,820	12,734,820	12,734,820	12,734,820	6,272,058	3,074,435	3,074,435	3,074,435	3,074,435
R-squared	0.299	0.305	0.312	0.305	0.313	0.268	0.272	0.276	0.272	0.276	0.537	0.535	0.535	0.535	0.535

Robust standard errors in parentheses, clustered at the firm-HS6-origin-year level.
*** p<0.01, ** p<0.05, * p<0.1

Table A4. The Distribution of China's NTMs by HS2 Sector

HS2	Industry	Total NTM	Chapter A-C
1	Live animals	3,645	2,968
2	Meat and edible meat offal	14,458	12,508
3	Fish and crustaceans, molluscs and others	19,454	15,499
4	Dairy produce, birds' eggs, natural honey	4,795	4,279
5	Products of animal origin	2,288	1,392
6	Live trees and other plants	784	548
7	Edible vegetables and certain roots and tubers	5,239	4,021
8	Edible fruit and nuts; peel of citrus fruit or melons	5,871	4,340
9	Coffee, tea, mate and spices	3,436	2,555
10	Cereals	5,622	2,677
11	Products of the milling industry, malt, starches	2,308	1,418
12	Oil seeds and oleaginous fruits	5,074	3,860
13	Lac, gums, resins and other vegetable saps and extracts	948	678
14	Vegetable plaiting materials	206	157
15	Animal or vegetable fats and oils	3,918	3,254
16	Preparations of meat, of fish or of crustaceans, molluscs	4,549	3,699
17	Sugars and sugar confectionery	1,076	858
18	Cocoa and cocoa preparations	568	458
19	Preps. of cereal, flour starch or milk	1,099	908
20	Preps. of vegetables, fruit, nuts or other parts of plants	3,260	2,733
21	Miscellaneous edible preparations	1,047	843
22	Beverages, spirits and vinegar	1,402	1,112
23	Residues and waste from the food industries	1,816	1,365
24	Tobacco and manufactured tobacco substitutes	388	282
25	Salt; sulphur; earths and stone	2,230	403
26	Ores, slag and ash	6,836	403
27	Mineral fuels, mineral oils and products of their distillation	10,007	491
28	Inorganic chemicals	7,772	1,956
29	Organic chemicals	8,375	4,621
30	Pharmaceutical products	1,860	892
31	Fertilizers	692	351
32	Tanning or dyeing extracts; tannins and their derivatives	1,479	503
33	Essential oils and resinoids, perfumery, cosmetic	1,136	692
34	Soap, organic surface-active agents	354	181
35	Albuminoidal substances; modified starches; glues; enzymes	1,083	810
36	Explosives; pyrotechnic products; matches	767	76
37	Photographic or cinematographic goods	281	76
38	Miscellaneous chemical products	19,610	745
39	Plastics and articles thereof	2,454	1,482
40	Rubber and articles thereof	1,584	888
41	Raw hides and skins and leather	4,848	3,576
42	Articles of leather, saddlery and harness, handbags	608	321
43	Furskins and artificial fur; manufactures thereof	797	553
44	Wood and articles of wood, wood charcoal	2,978	1,752
45	Cork and articles of cork	246	162
46	Manufactures of straw, of esparto or of other plaiting materials	350	167
47	Pulp of wood or of other fibrous cellulosic material	955	216
48	Paper and paperboard; articles of paper pulp	1,121	455
49	Printed books, newspapers	248	63
50	Silk	265	131

Table A4. The Distribution of China's NTMs by HS2 Sector (Continued)

HS2	Industry	Total NTM	Chapter A-C
51	Wool and fine or coarse animal hair, inc. yarns, woven fabrics	2,737	1,838
52	Cotton	2,359	618
53	Other vegetable textile fibres	665	330
54	Man-made filaments	1,030	242
55	Man-made staple fibres	1,530	348
56	Wadding, felt and nonwovens; special yarns	480	145
57	Carpets and other textile floor coverings	520	217
58	Special woven fabrics; tufted textile fabrics; lace	549	128
59	Impregnated, coated, covered or laminated textile fabrics	346	81
60	Knitted or crocheted fabrics	653	156
61	Articles of apparel and clothing accessories, knitted or crocheted	2,329	696
62	Articles of apparel and clothing accessories, not knitted or croche	2,507	829
63	Other made up textile articles	934	338
64	Footwear, gaiters and the like	557	267
65	Headgear and parts thereof	119	37
66	Umbrellas, sun umbrellas, walking-sticks, seat-sticks	116	39
67	Prepared feathers and down and articles made of feathers or of do	229	130
68	Articles of stone, plaster, cement, asbestos, mica or similar materi	1,256	315
69	Ceramic products	449	230
70	Glass and glassware	1,630	581
71	Natural or cultured pearls	3,124	971
72	Iron and steel	3,076	1,055
73	Articles of iron or steel	2,050	807
74	Copper and articales thereof	592	272
75	Nickel and articles thereof	224	96
76	Aluminium and articles thereof	474	220
78	Lead and articles thereof	710	55
79	Zinc and articles thereof	136	73
80	Tin and articles thereof	137	49
81	Other base metals	5,895	460
82	Tools, implements, cutlery, spoons and forks, of base metal	952	439
83	Miscellaneous articles of base metal	397	163
84	Nuclear reactors	259,506	6,007
85	Electrical machinery and equipment and parts thereof	128,993	3,627
86	Railway or tramway locomotives, rolling-stock and parts thereof	5,728	124
87	Vehicles other than railway or tramway rolling-stock	4,598	1,410
88	Aircrafts, spacecraft and parts thereof	189	65
89	Ships, boats and floating structures	259	119
90	Optical, photographic, cinematographic	12,337	2,045
91	Clocks and watches and parts thereof	11,612	293
92	Musical instruments	1,666	187
93	Arms and ammunition	373	129
94	Furniture	1,150	226
95	Toys, games and sports requisites	1,648	195
96	Miscellaneous manufactured articles	2,561	363
97	Works of art, collectors' pieces and antiques	206	77
	Total	641,775	121,470

Source: Author's calculations on the UNCTAD TRAINS database.