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Enforcement of Non-Tariff Measures: Does it matter?

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Abstract

We show, theoretically and quantitatively, that the way non-tariff measures (NTMs) are enforced matter for trade and welfare. If enforcement entails a per shipment cost, in equilibrium NTMs take the form of an implicit an-valorem tariff and affect both the intensive and extensive margins of trade. Per shipment costs resulting from NTMs are particularly damaging for smaller, less productive exporters. We argue that NTMs should be enforced in ways that do not create per shipment costs.

Keywords: Non-tariff measures, Per shipment costs, Enforcement

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1. Introduction

Import tariffs are at an all-time low level. In 2017, the weighted mean of import tariffs across all countries and products stood at slightly above 2.5 percent (UNCTAD). Barring a few products, there is not much scope for achieving significant increase in trade through further reductions in import tariff rates. Consequently, attention has recently shifted to other trade barriers, notably non-tariff measures or NTMs. This paper highlights a hitherto unexplored channel through which NTMs can affect the export cost of firms, and create large welfare losses.

We begin by arguing that the implementation of certain NTMs results in the creation of a *per shipment* cost, trade costs that are independent of the size and value of the shipment but are incurred every time an exporter sends a shipment. This is the case, for instance, when the enforcement of a Phytosanitary or a Technical measure requires the inspection of (some) shipments. Following Blum et al. (2019), we then write down a heterogenous firm model where exporters, selling differentiated varieties, solve an inventory management problem.[1] The presence of inventory management costs and per shipment costs implies that exporters face a trade-off: more shipments implies smaller inventory and lower losses from holding inventory but higher per shipment costs. We solve for the optimal shipment size and frequency of the exporter as a function of, among other things, per shipment costs.

In this setting, when per shipment costs rise, exporters choose to send fewer and larger shipments. This results in inventory in the importing country that, on average, is larger in size. Because the marginal cost of an exporter is the sum of the marginal production and distribution costs, where the latter depends on the leakage from holding inventories, a higher per shipment cost leads to a higher marginal cost. Furthermore, these *marginal distribution costs* are higher for less productive firms whose ability to reduce shipment frequency is limited by their scale.

We compare a NTM whose enforcement entails a one time fixed cost with one that entails a per shipment cost. Because any exporting cost might affect the participation

[1] Using Chilean customs data, Blum et al. (2019) established that Chilean importers seem to be solving a non-trivial inventory management problem.

constraint of the exporter, we assume that exporters are provided a transfer that equals the additional cost that arises due to the NTM. Under this assumption, a fixed cost of enforcement has no effect on trade. A per shipment cost, however, does lower the intensive (sales of individual varieties) as well as the extensive (total number of varieties) margins of trade. If the exported product is a final good, this directly lowers consumer welfare in the importing country in general.

Furthermore, if the exported product is an intermediate input, a reduction in the number of varieties results in a decline in the productivity of the importing firm, which in turn has consequences for welfare as well. Indeed, recently available firm-level evidence has established that access to imported intermediate inputs raises firms' productivity (see Amiti and Konings (2007), Kasahara and Rodrigue (2008), Goldberg et al. (2010), and Khandelwal and Topalova (2011) for static productivity gains, and Boler et al. (2015) and Fieler et al. (2018) for dynamic gains). Imported inputs raise local firms' productivities, especially in developing countries, because they are of higher quality and they add to the variety of inputs used by the firm (Halpern et al., 2015). This paper highlights that, depending on enforcement, NTMs can affect countries' ability to import intermediate inputs.

In general, eliminating NTMs is not feasible because they typically allow countries to achieve certain national objectives such as protecting consumers' health. This paper, however, makes the point that how NTMs are enforced matters. In particular, it argues that NTMs should be enforced in ways that do not create per-shipment costs. In the final part of the paper, we carry out a quantitative exercise to back up our claim. We show that per shipment costs have a disproportionately large negative effect on the smallest, least productive exporters, even when these firms are compensated for the additional costs imposed by the NTM. Moreover, if imported varieties are not easily substitutable or if the costs of holding inventories are large, the per-shipment costs created by NTMs can have large welfare effects in the importing country.

The plan of this paper is as follows: We begin by pointing out that the ways countries enforce NTMs are very obscure. From what we could find out, however, a significant share of the NTMs currently in place create costs that have a per shipment component. We then discuss the existing literature on NTMs and highlight the contribution of our paper. The following section presents our model of trade and distribution, and discusses our main theoretical results. We conclude by carrying out a quantitative exercise that highlights the potential costs imposed by NTMs that create a per shipment cost.

2. NTMs and Per Shipment Costs

This is what the UNCTAD has to say about NTMs: "*Non-tariff measures (NTMs) are policy measures other than tariffs that can potentially have an economic effect on international trade in goods. They are increasingly shaping trade, influencing who trades what and how much. For exporters, importers and policymakers, NTMs represent a major challenge. Though many NTMs aim primarily at protecting public health or the environment, they also substantially affect trade through information, compliance and procedural costs.*"[2]

Collecting data on NTMs is, however, a daunting task. Unlike tariffs, NTMs are not numbers but rather regulations that are typically spread across different regulatory agencies of a country. UNCTAD has been collecting and harmonizing data on NTMs since 1994 and has made it available through their Trade Analysis and Information System (TRAINS) database. As of 2017, TRAINS contains around 55,000 measures from 109 countries.

Information on how the NTMs in the books are actually enforced is basically unavailable. The authors of this paper reached out to officials in charge of international trade in three countries, one in Asia, one in North America, and one in South America, and were not able to find transparent and consistent descriptions of how these countries enforce the NTMs they impose.

TRAINS

The TRAINS database classifies existing NTMs into several categories. These include

[2] https://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures.aspx

sanitary and phytosanitary (SPS) measures, technical barriers to trade (TBT), prohibitions, pre-shipment inspections, quotas, , etc. Several of such measures could result in a cost that has to be incurred per shipment, depending on how they are enforced. To illustrate:

1. There are technical barriers to trade (TBT) that restrict the use of certain substance, e.g. maximum level of lead in paint, or impose labelling requirements, e.g. labels on refrigerators indicating the electricity consumption levels. To ensure that such TBT requirements have been made, tests and inspections are randomly carried out on shipments in the importing country.
2. There are pre-shipment inspection requirements whereby shipments need to be inspected by an independent agency prior to being shipped from the exporting country. E.g. prior to shipping, textiles could be inspected by an agency to verify the type of material used.

Statutes of the Singapore Government

One exception to the rule is the Singaporean Government. The Legislation Division of the Attorney-General's Chambers, the central law drafting office of Singapore, publishes statutes that describe, among other things, how the NTMs imposed by this country should be implemented. We analysed 59 of these statutes and found that 53 percent of the products which are under the purview of these statutes face a NTM comprising of a per-shipment cost component.

We classified the NTMs under the purview of these statutes in two groups, depending on whether they created per-shipment cost or not. An NTM is said to have a per-shipment cost component if it is ascribed in the statute that "*an inspecting officer, at any reasonable time, can enter and inspect any premises or conveyance and can open any box or consignment, take such item thereof for further inspection*". It is to be noted here that certain NTMs allow an inspecting officer to enter and inspect premises or conveyance without opening any box or consignment, as part of a routine inspection. We did not classify this NTM as inclusive of per-shipment cost.

Of all the statutes analysed, we found that 14 of the statutes constitute a per-shipment cost component and 1151 products fall exclusively under the purview of these 14 statutes. Another 1057 products fall under the statutes which do not have a per-shipment cost component and, the rest 255 products fall under both the groups. We observed that NTMs relating to medicine (both health products and drugs) and food (consisting of meat, fish and plants) typically consist of the per-shipment cost component. Other NTMs in this category are related to import/export of endangered species, telecommunication instruments and, explosives.

International Trade Centre (ITC) NTM Business Survey

Another great source of indirect information regarding how the implementation of NTMs has affected different types of firms is the International Trade Centre (ITC) NTM Business Survey data. Based on 14,000 interviews with companies in 25 different countries, it helps us to identify the significant regulatory and procedural obstacles to trade and understand why specific types of NTMs pose a hindrance.

In South-East Asia, firms from three countries were surveyed – Indonesia, Sri Lanka and Cambodia. The survey for Indonesia and Cambodia took place in 2012-13 whereas, for Sri Lanka, it was done during 2010. It was observed that 37 percent of companies interviewed in Indonesia, 43 percent in Sri Lanka and 69 percent in Cambodia were affected by NTMs. Additionally, it was observed that small firms are more affected than large firms in all three countries.

Among the exporting firms in Indonesia, around 40 percent of the surveyed firms listed “Technical requirements” as a burdensome NTM, followed by “Export-related measures” (34 percent), “Conformity assessment” (16 percent) and “Rules of origin and related certificate of origin” (7.3 percent). For the importing firms, the most burdensome NTM is “Pre-shipment inspection and other entry formalities”, which was listed by more than 55 percent of the firms, followed by “Quantity control measures” (13.5 percent), “Conformity assessment” (10.1 percent), “Technical requirements” (9 percent) and “Export related measures” (6.7 percent). Time constraints have been cited as the primary reason behind procedural obstacles followed by informal payments (bribery) or unusually high fees and charges and discriminatory behaviour of the inspecting officials.

3. Literature review on NTMs

The literature on non-tariff trade measures (NTM) primarily looks at the impact of product standards imposed by developed countries on exports from developing countries, and misses the possible implications of how these measures are enforced. It has been hypothesised that due to lack of public resources in the developing economies, the cost of compliance is almost entirely borne by the individual firms, which adds to costs and limits the competitiveness of these firms (Maskus et al., 2005). A report on non-tariff trade barriers by the UNCTAD in 2005 found that in spite of low tariffs, many developing economies have failed to export their manufactured goods to developed countries due to non-compliance of the stringent standards imposed by the latter.

Using firm level data from the World Bank Technical Barriers to Trade (TBT), Maskus et al. (2005) gave the first estimate of the impact of standards and technical regulations imposed by developed nations on developing country firms. They found out that a 1 percent increase in investment cost to meet the standards imposed by the exporting countries increased variable cost of production by 0.06 percent to 0.13 percent. In their paper, they used the relative incremental setup cost incurred for the standards compliance as the measure of stringency.

Using the same dataset, Chen et al. (2008) found out heterogeneous impact of different types of technical measures on developing country firms' export behaviour. Their paper examined the effect of four types of standards (quality standards, design standards, testing and certification procedures and labelling requirements) on the intensive margin as well as two measures of extensive margin: number of markets and number of products exported by the firms. They found that quality standards and labelling requirements have a large positive correlation with both the intensive and extensive margins of firms' exports, whereas certification procedures are negatively associated with both intensive and extensive margins.

Standards can also affect trade among developed countries, such as the harmonisation of European product standards to international norms in the electronics sector. Reyes (2011) exploits this reduction in NTM to estimate the response of U.S. manufacturing firms and finds that this reduction increases US exports to EU primarily due to the entry of new US firms in the EU market. These firms were typically smaller and less productive than incumbent firms. But the harmonisation also caused export from existing exporters to decrease.

On the other hand, imposition of compliance cost can also lead to a situation where the smaller firms are more adversely impacted as compared to larger firms who can bear this cost (Fontagné et al., 2015). By matching a detailed panel of French firm exports to a new database of Sanitary and Phytosanitary (SPS) regulatory measures, Fontagné et al. (2015) showed that the imposition of a restrictive SPS measure had an adverse impact on both the extensive and intensive margins.

The papers mentioned above examine the correlation of various NTMs with intensive and extensive margins of trade. There is another set of papers that attempt to quantitatively measure the effect of NTMs. These papers combine the observed change in import of a given product (possibly due to a NTM) and a measure of the import elasticity to calculate the ad valorem equivalent (AVE) of a NTM.[3] Papers in this tradition include Kee et al. (2008); Cadot and Gourdon (2016); Ghodsi et al. (2016); Kee and Nicita (2016) and Cadot et al. (2018), among others.

The evidence that NTMs affect both the extensive and the intensive margins of trade indicate that these measures create both fixed and variable trade costs. The literature has not, however, investigated the possibility that NTMs create per-shipment costs as well. This paper is an attempt to close this gap.

4. The model

We closely follow the framework developed in Blum et al. (2019). We focus on the import of varieties, denoted by i, of a differentiated good from a foreign country into the home country. Assume for simplicity that the home does not produce this good. Home

[3] The AVE is the ad valorem tariff that would also lead to the observed decline in imports.

consumers have CES preference over the continuum of varieties:

$$U = \Big[\int_i x(i)^{\frac{\sigma-1}{\sigma}} di\Big]^{\frac{\sigma}{\sigma-1}},$$

where σ is the constant elasticity of substitution. The corresponding aggregate price index is

$$P = \Big[\int p(i)^{1-\sigma} di\Big]^{\frac{1}{1-\sigma}}.$$

Given the utility function, P is the cost of consuming one unit of utility. If E is the total expenditure on this good, the demand for each variety is then given by

$$x(i) = \frac{p(i)^{-\sigma}}{P^{1-\sigma}} E.$$

We assume that the demand for each variety is spread uniformly over the time interval $[0, 1]$, i.e., in the interval dt, demand for variety i is $x(i)dt$.

The foreign varieties are imported and sold in the home country through a perfectly competitive distribution sector. Normally, distribution entails four costs. First, there are the usual iceberg trade costs. This could involve costs incurred due to transportation, insurance, tariff, etc. Second, there are fixed costs of exporting. Such costs could arise due to marketing efforts, acquiring information about the home country, etc. Third, implementation of some of the NTMs could impose a per shipment cost. For example, to ensure that the imported products meet standards, shipments could be inspected at random. And finally, there is an ad-valorem depreciation cost of inventory. If the distributor chooses to carry an inventory, a fraction of it depreciates in every time interval dt. To focus on the inventory management problem, we assume that trade costs are zero. To allow the extensive margin to play a role, however, we do not set the fixed costs to zero.[4] The fixed, per shipment and depreciation costs are captured by F, K and δ respectively.

Because the distribution sector is perfectly competitive, the final price of an im-

[4]Another reason for allowing a non-zero fixed cost is that in the next section, we calibrate some of the model parameters by matching moments that exploit the selection of some but not all foreign firms into exporting. In the absence of fixed costs, such a selection will not occur.

ported variety sold at home is the free-on-board (FOB) price in the foreign country plus any additional distribution cost. The presence of an inventory management problem implies that the latter is endogenous: the distributor chooses the size and frequency of shipments to minimize the total cost (which includes the cost of production). We turn to this problem next.

An inventory management problem.

Let a distributer's inventory at time t be denoted by $m(t)$. Inventory depletes because the distributer sells a constant amount every period and because inventory also depreciates at a rate of δ. Assuming that the distributor receives no shipments at t, the law of motion of inventory is given by

$$\frac{dm(t)}{dt} = -x(i) - \delta m(t).$$

In Blum et al. (2019), we show that given the uniform demand assumption, the optimal shipping policy must satisfy two properties: First, a foreign shipment for variety i must arrive in the home country when inventory is zero. Second, shipments should be of equal size, arriving at equal intervals. This symmetry in the shipping decision reduces the distributor's problem of minimizing total cost, $c(i)$, to a static optimization problem:

$$c(i) = \min_{n(i),s(i)} n(i)\big(K + r(i)s(i)\big) \tag{1}$$

where $n(i)$ and $s(i)$ denote the number and size of shipments respectively, while $r(i)$ is the marginal cost of producing variety i. The above equation illustrates how the presence of per shipment cost, K, and depreciation cost, δ, creates a trade-off: On the one hand, fewer shipments mean that the the distributor has to incur the per shipment cost fewer times. On the other hand, the distributor then has to hold a bigger inventory on average, resulting in higher wastage due to depreciation.

Notice that conditional on demand, once the distributor chooses the shipment frequency, shipment size is determined. The law of motion of inventory, combined with properties of optimal inventory policy, yields

$$s(i) = \frac{x(i)}{\delta}\left(e^{\delta/n(i)} - 1\right).$$

Replacing $s(i)$ in (1), the distributor's cost minimization problem reduces to solving a non-linear equation in $n(i)$ as indicated in the following lemma.

Lemma 1. *Optimal $n(i)$ solves the following implicit equation:*

$$e^{\delta/n(i)}\left(\frac{1}{\delta} - \frac{1}{n(i)}\right) = \frac{1}{\delta} - \frac{K}{r(i)x(i)}. \tag{2}$$

For the distributor to hold zero inventory, shipments must be arriving continuously in the home country. But notice that as $n(i) \to \infty$, the left-hand side of (2) converges to $\frac{1}{\delta}$ while the right-hand side remains unchanged. The only way this can be an equilibrium is if $K = 0$. This makes sense. When $n(i) \to \infty$, the distributor has an arbitrarily large number of shipments. Unless $K = 0$, the total shipment cost explodes. Hence, $K > 0$ implies that a distributor has a finite number of shipments and holds inventory to smooth demand. The next proposition provides a key characterization of the optimal number of shipments:

Proposition 1. *Conditional on demand, the number of shipments is lower, and shipment size is higher, the higher is the per shipment cost.*

In equilibrium, the distributor equates the marginal increase in the cost of a shipment with the marginal increase in savings from lower inventory. Accordingly, when per shipment costs rise, efficiency requires that the distributor reduce the number of shipments, while increasing their size. At the optimal $n(i)$, the total cost reduces to

$$c(i) = e^{\delta/n(i)} r(i)x(i).$$

In the presence of an inventory management problem, the total cost is no longer simply the total cost of producing the quantity demanded – $r(i)x(i)$. Rather, it is proportional itself to $r(i)x(i)$, with the factor of proportionality being endogenous.

Optimal price.
Now consider the problem of a foreign exporter of variety i who is choosing at what price to sell in the home country. Firms engage in monopolistic competition. Each firm chooses the price that maximizes profit, taking into account the problem solved by the distribution sector:

$$\pi(i) = \max_{p(i)} \big(p(i) - e^{\delta/n(i)} r(i)\big) x(i),$$

where $x(i) \propto p((i)^{-\sigma}$. Monopolistic competition implies that individual firms take the aggregate price index, P, as given. The following proposition provides the solution of the above problem.

Proposition 2. *The exporter's profit-maximizing price is given by*

$$p(i) = \frac{\sigma}{\sigma - 1}\big(1 + d(i)\big) r(i),$$

where

$$d(i) = \frac{e^{\delta/n(i)} - 1 - \delta/n(i)}{\delta/n(i)}.$$

In the presence of per shipment costs, the optimal price charged by the exporter is still a constant mark-up over the marginal cost. But the latter consists of both the marginal production cost, $r(i)$, as well as the *marginal distribution cost*, captured by the term $d(i)$. Because average inventory size is non-zero, the exporter loses some units due to depreciation. The loss of these units effectively raises the cost of the remaining units: per shipment cost ends up imposing an ad-valorem cost on exporters. Observe that this cost is endogenous as it depends on the frequency of shipments.

Proposition 2 provides a key insight: how NTMs are enforced matters. If the enforcement entails the exporter incurring a one time cost of compliance, e.g. getting a certificate from relevant authorities, prices will not be affected. In this event, if the fixed cost incurred by the exporter on account of the NTM is reimbursed, there will not be any change in firm level variables, either at the intensive or the extensive margin.

If, on the other hand, enforcement entails the exporter incurring a cost every time a shipment is sent, e.g. random inspection, prices will be affected. In this case, the NTM, by affecting adjustments not just along the intensive but the extensive margin as well, could have a large effect on welfare.

Next, we impose more structure on the supply side. Following Melitz (2003), we assume that production requires only labour: an exporter uses $1/\theta$ units of labour to produce output, where θ is drawn from some distribution $G(\theta)$. Hence, θ captures the productivity of an exporter. Given the nature of competition, every exporter produces a unique product but all exporters with the same productivity are symmetric. Accordingly, we can label an exporter by his productivity. Consider two exporters with productivity θ_1 and θ_2 with $\theta_1 > \theta_2$. Setting the foreign wage to one, the ratio of their prices is given by

$$\frac{p(\theta_1)}{p(\theta_2)} = \Big(\frac{e^{\delta/n(\theta_1)} - 1}{e^{\delta/n(\theta_2)} - 1} \times \frac{n(\theta_1)}{n(\theta_2)}\Big)\frac{\theta_2}{\theta_1}.$$

With a non-trivial inventory management problem, it can be shown that

$$\frac{p(\theta_1)}{p(\theta_2)} < \frac{\theta_2}{\theta_1}.$$

Observe that in a standard problem, the ratio of prices equals the ratio of marginal production costs. When NTMs have a per shipment component, although the equilibrium price goes up, it goes up relatively more for less productive foreign exporters. Intuitively, the *marginal distribution costs* go up more for less productive firms whose ability to reduce shipment frequency is limited by their scale. Accordingly, the sales shares increase for the more productive exporters. In a standard heterogenous firm framework, the more productive exporters also happen to be the larger exporters. Hence, NTMs that create a per shipment cost makes the sales distribution more skewed than suggested by the underlying productivity distribution. We summarize in the following proposition:

Proposition 3. *The presence of per shipment and inventory costs causes the distribution of sales to be skewed towards the more productive exporters.*

5. Quantitative exercise

NTMs allow countries to achieve certain objectives such as protecting consumers' health, the environment, etc. Accordingly, eliminating NTMs is not feasible. Our theoretical analysis, however, suggests that NTMs could be particularly damaging if they end up creating a per shipment cost. In this section, we quantitatively evaluate the costs that accrue to importing countries when NTMs are implemented in a way that imposes a per shipment cost. In particular, we shall evaluate how the extensive and intensive margins change with different level of the per shipment cost relative to the frictionless scenario without an inventory management problem.

To proceed, we need values for the following model parameters: the elasticity of substitution, σ, the fixed exporting cost, F, the depreciation rate, δ, and the underlying productivity distribution, $G(\theta)$. For SITC-3 digit product codes, Broda and Weinstein (2006) estimated a mean σ of 4 and a median σ of 2.2. We pick $\sigma = 4$ for our benchmark scenario. Following Blum et al. (2019), we choose $\delta = 0.3$ for our benchmark scenario. The productivity distribution and F are calibrated to match certain data moments in the size distribution for U.S. manufacturing firms. The underlying assumption is that the benchmark size distribution matches that from the U.S.

Moment	Value	Source
Exporting firms as a share of all firms	0.18	Bernard et al. (2007)
Ratio of average sales of exporters to non-exporters	4.5	Bernard et al. (2007)
Ratio of 90th to 10th percentile of total sales	50	Armenter and Koren (2015)

Table 1: Targeted moments

We assume that the underlying productivity distribution is a truncated Pareto with shape parameter α and range $[\underline{\theta}, \bar{\theta}]$ (Helpman et al., 2008). We normalize $\underline{\theta}$ to 1. We calibrate $\bar{\theta}$, α and F to match three moments from the U.S. firm size distribution: the share of firms that export, the average sales of exporters relative to that of non-exporters, and the ratio of the sales of the firm at the 90th percentile of sales distribution to the firm at the 10th percentile. This gives us $\underline{\theta} = 3.5, \alpha = 7, F = 0.23$.[5] Table 1 summarizes the moments that we target.

Having calibrated the main model parameters, we proceed to perform the following counterfactual. NTMs, irrespective of the form that they take, impose cost on the exporters. We consider a scenario where the additional distribution cost that foreign exporters have to incur on account of the per shipment nature of the NTMs are reimbursed by the home government in the form of a lumpsum transfer. Hence, if the NTM does not affect the optimal price of an exporter, it will not affect either the sales or the decision to export.

Results.

To illustrate how per shipment costs affect aggregate trade, we examine the following six equilibrium objects: average (a) frequency and (b) size of shipments, (c) per shipment cost as a share of average shipment size, (d) average marginal distribution cost, (e) fraction of exporters relative to the frictionless scenario and (f) aggregate price index relative to the frictionless scenario. Note that even in the frictionless (no inventory management) scenario, some foreign firms may not export because of the fixed cost. (e) is meant to capture any additional selection owing to the per shipment cost. In this model, we assumed that the good in consideration is not produced in the home country. The model then is essentially partial equilibrium and one cannot measure welfare without closing the model. Nevertheless, the change in the aggregate price index of the imported varieties will affect welfare. That is what (f) is meant to capture.

We measure all the six equilibrium objects mentioned above for four different values of the per shipment cost, K – 2 percent, 5 percent, 10 percent and 20 percent of the fixed exporting cost. Table 2, Panel B shows the results for $\alpha = 7, \sigma = 4, \delta = 3$. As K increases, the average number of shipments falls while the average size of shipments rises, consistent with Proposition 1. The average marginal distribution cost also rises from 2 percent to 8 percent. Keep in mind though that as K rises, the set of exporters declines, with the ones that switch export status facing the largest marginal distribu-

[5]In order to compute total sales, we assume that a firm's export revenue is 10 percent of its total revenue.

tion costs. The average reported here takes this into account by considering both exporters and non-exporters. With an increase in K, the number of exporters declines even relative to the frictionless case. This suggests that the participation constraint of the exporters is affected in the presence of per shipment cost, *despite the exporters getting a transfer equal to their distribution cost.* The aggregate price index rises with K, both due to higher prices charged by continuing exporters as well as reduction in the number of exporters.

How does the effect of per shipment costs on trade depend on industry/product characteristics? To answer this question, we look at three different attributes: (i) the degree of concentration in the industry, captured by α, (ii) the degree of product differentiation, captured by σ, and (iii) the shelf-life of a product, captured by δ. A higher α, in our formulation, corresponds to a more skewed distribution of productivity and accordingly, a more skewed firm size distribution. Similarly, a higher σ corresponds to higher substitutability between varieties and reduces firms' ability to raise prices. And finally, a higher δ characterizes goods that have a low shelf-life. This could either be because high δ goods are more perishable (e.g. apples), or because their demand exists for a shorter time span (e.g. fast fashion items) relative to low δ goods.

Table 2 shows the results for different values of α. As we move from Panel A to Panel C, the value of α rises from 5 to 9. As the share of smaller firms rises, the average shipment frequency declines for all values of K. As α rises, more firms also select out of exporting, even relative to the frictionless case. For example, when K is 10 percent of F, the share of exporters relative to the frictionless case declines from 0.83 ($\alpha = 5$) to 0.71 ($\alpha = 9$). Once again, this decline happens despite the foreign firms getting reimbursed for the distribution cost. The higher decline in exporting firms when α is high is reflected in a higher aggregate price index.

Table 3 shows the results for different values of σ. As we move from Panel A to Panel C, the value of σ rises from 2 to 6. When the imported varieties have low substitutability, individual firms charge higher prices even without inventory management. Higher price reduces demand, which, in the presence of inventory management, causes both shipment frequency and shipment size to be lower. This pushes up

	K (share of F)			
	2 %	5 %	10%	20%
Panel A: $\alpha = 5$				
Average shipment frequency	5.43	3.43	2.48	1.43
Average shipment size	0.24	0.36	0.50	0.75
Per shipment cost/average shipment size	0.02	0.03	0.05	0.06
Average marginal distribution cost	0.02	0.04	0.06	0.08
Exporters relative to frictionless	0.91	0.91	0.83	0.83
Aggregate price index relative to frictionless	1.05	1.06	1.09	1.13
Panel B: $\alpha = 7$				
Average shipment frequency	5.07	3.10	2.25	1.24
Average shipment size	0.21	0.32	0.45	0.68
Per shipment cost/average shipment size	0.02	0.04	0.05	0.07
Average marginal distribution cost	0.02	0.04	0.06	0.08
Exporters relative to frictionless	0.87	0.87	0.77	0.77
Aggregate price index relative to frictionless	1.06	1.08	1.12	1.18
Panel C: $\alpha = 9$				
Average shipment frequency	4.83	2.90	2.14	1.14
Average shipment size	0.20	0.31	0.42	0.64
Per shipment cost/average shipment size	0.02	0.04	0.06	0.07
Average marginal distribution cost	0.02	0.04	0.06	0.08
Exporters relative to frictionless	0.84	0.84	0.71	0.71
Aggregate price index relative to frictionless	1.07	1.09	1.16	1.23

Table 2: Comparative statics (different α)

	K (share of F)			
	2 %	5 %	10%	20%
Panel A: $\sigma = 2$				
Average shipment frequency	2.45	1.19	1.00	1.00
Average shipment size	0.11	0.23	0.25	0.25
Per shipment cost/average shipment size	0.04	0.05	0.09	0.18
Average marginal distribution cost	0.04	0.08	0.13	0.17
Exporters relative to frictionless	1.00	1.00	1.00	1.00
Aggregate price index relative to frictionless	1.07	1.14	1.17	1.18
Panel B: $\sigma = 4$				
Average shipment frequency	5.07	3.10	2.25	1.24
Average shipment size	0.21	0.32	0.45	0.68
Per shipment cost/average shipment size	0.02	0.04	0.05	0.07
Average marginal distribution cost	0.02	0.04	0.06	0.08
Exporters relative to frictionless	0.87	0.87	0.77	0.76
Aggregate price index relative to frictionless	1.06	1.08	1.12	1.18
Panel C: $\sigma = 6$				
Average shipment frequency	6.67	4.64	3.20	2.37
Average shipment size	0.43	0.55	0.71	1.04
Per shipment cost/average shipment size	0.01	0.02	0.03	0.04
Average marginal distribution cost	0.02	0.03	0.04	0.05
Exporters relative to frictionless	1.00	1.00	1.00	0.77
Aggregate price index relative to frictionless	1.02	1.03	1.04	1.07

Table 3: Comparative statics (different σ)

	K (share of F)			
	2 %	5 %	10%	20%
Panel A: $\delta = 0.1$				
Average shipment frequency	2.69	1.56	1.11	1.02
Average shipment size	0.39	0.70	0.92	1.01
Per shipment cost/average shipment size	0.01	0.02	0.02	0.04
Average marginal distribution cost	0.01	0.02	0.03	0.04
Exporters relative to frictionless	1.00	0.87	0.87	0.87
Aggregate price index relative to frictionless	1.02	1.06	1.07	1.08
Panel B: $\delta = 0.3$				
Average shipment frequency	5.07	3.10	2.25	1.24
Average shipment size	0.21	0.32	0.45	0.68
Per shipment cost/average shipment size	0.02	0.04	0.05	0.07
Average marginal distribution cost	0.02	0.04	0.06	0.08
Exporters relative to frictionless	0.87	0.87	0.77	0.76
Aggregate price index relative to frictionless	1.06	1.08	1.12	1.18
Panel C: $\delta = 0.5$				
Average shipment frequency	6.43	4.00	2.70	1.90
Average shipment size	0.16	0.24	0.34	0.50
Per shipment cost/average shipment size	0.03	0.05	0.07	0.09
Average marginal distribution cost	0.03	0.05	0.08	0.12
Exporters relative to frictionless	0.87	0.87	0.77	0.52
Aggregate price index relative to frictionless	1.07	1.09	1.15	1.30

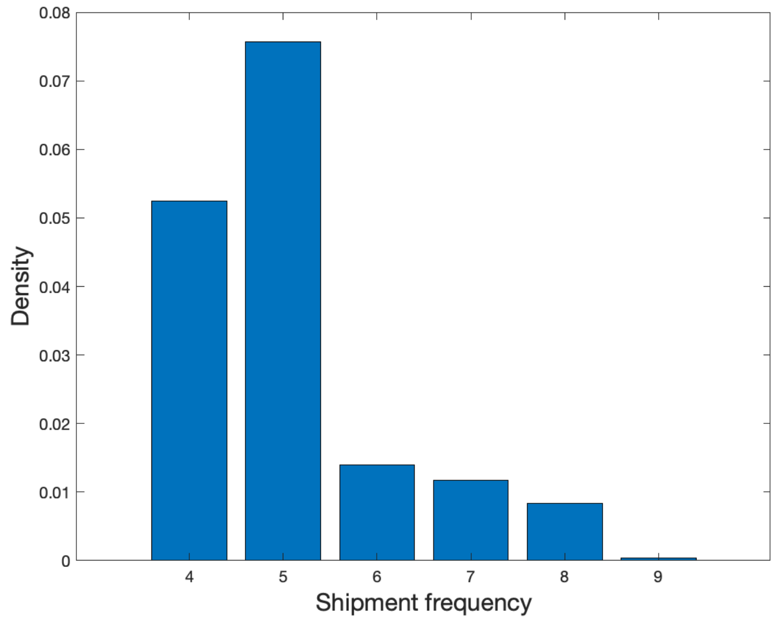
Table 4: Comparative statics (different δ)

the average marginal distribution cost, raising prices further. For example, when K is 10 percent of F, the marginal distribution cost rises from 0.04 ($\sigma = 6$) to 0.13 ($\sigma = 2$). The inability of consumers to substitute away from more expensive varieties results in a higher aggregate price index.

Finally, Table 4 shows the results for different values of δ. As we move from Panel A to Panel C, the value of δ rises from 0.1 to 0.5. When goods are more perishable or go out of fashion faster, distributors would like to hold smaller inventories. This causes shipments to be more frequent. For example, when K is 10 percent of F, the average shipment frequency rises from 1.11 ($\delta = 0.1$) to 2.70 ($\delta = 0.5$). A higher depreciation cost also ends up raising the marginal distribution cost, causing some firms to switch out of exporting. Furthermore, when δ is high, the negative effect of higher per shipment cost is particularly damaging: with $\delta = 0.5$ and K at 20 percent of F, the share of exporters relative to the frictionless case drops to 0.52, with the corresponding aggregate price index rising by 30 percent.

All the results presented until now pertain to averages for the entire industry. But as we showed in the previous section, per shipment costs affect firms of different productivity in different ways. We explore this next for the benchmark scenario where $\alpha = 7, \sigma = 4, \delta = 3$ and per-shipment costs are 2 percent of the fixed cost. More productive firms not only sell more, they also have more frequent shipments. As displayed in Figure 1, the least productive exporters have 4 shipments while for the most productive exporters, the corresponding number is 9.

Heterogeneity in the shipment frequency also results in heterogeneity in the marginal distribution cost. As displayed in Figure 2, more productive firms have a lower marginal distribution cost. The per shipment costs in the benchmark scenario imposes an ad-valorem tariff that ranges from less than 2 percent for the most productive firms to more than 5 percent for the least productive firms. Note that the firms facing more than 5 percent ad-valorem tariff do not export. Recalling that the fraction of exporters relative to the frictionless scenario is less than one, some of the firms which would have exported in the absence of inventory management opt out of exporting due to the high ad-valorem tariffs.

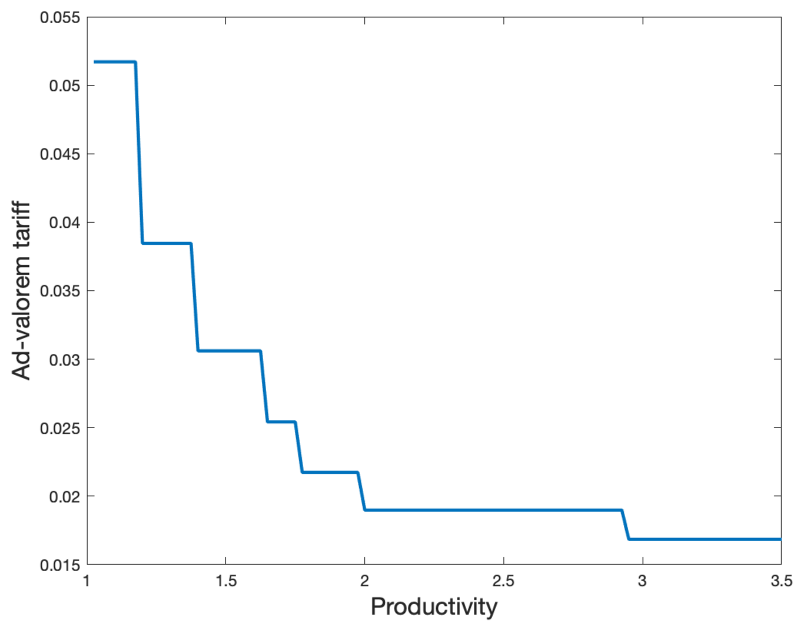


Note: The plot shows the distribution of the optimal frequency of shipments for the exporters. Firms with optimal shipment frequency of 3 or less do not export. $\alpha = 7, \sigma = 4, \delta = 3$.

Figure 1: Distribution of shipment frequency

Proposition 3 established that the per shipment costs, by negatively affecting the less productive firms relatively more, will cause the sales distribution to become more skewed. Figure 3 shows the export values of the firms, relative to the frictionless scenario. Per shipment cost causes sales to decline for all firms. But while it falls by around 7 percent for the most productive firms, the decline for the least productive firms is almost 14 percent.

The above analysis suggests that NTMs that create per shipment costs have a disproportionately large negative effect on the smallest, least productive foreign firms, despite the firms being compensated by the government for the additional costs. In the event that there is a relatively large mass of low productivity firms (high α) or varieties are not substitutable (low σ), NTMs can have large effects on welfare.



Note: $\alpha = 7, \sigma = 4, \delta = 3$

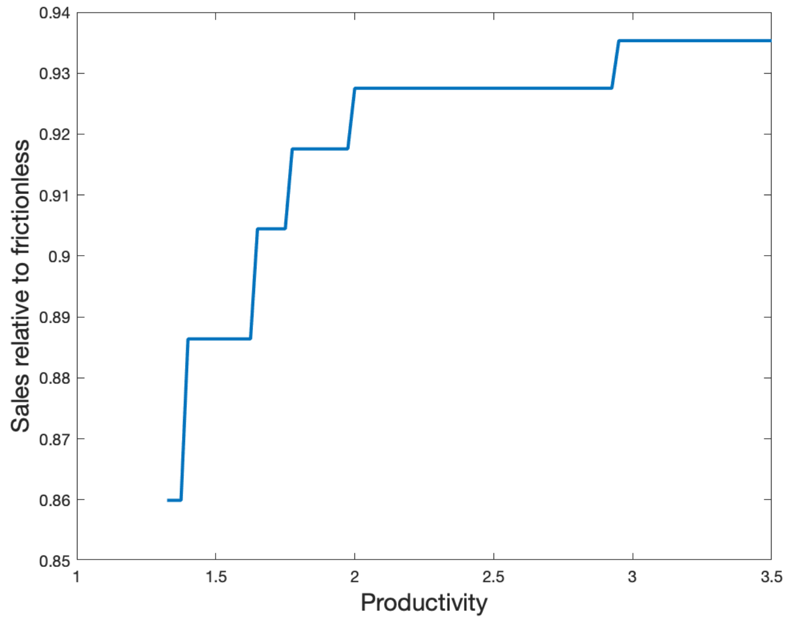
Figure 2: Ad-valorem tariff equivalent of NTM

6. Conclusion

A multitude of trade agreements has effectively reduced tariffs to a point at which the most important policy-induced costs to international trade are the so-called Non-Tariff Measures. Differently than tariffs, NTMs are particularly difficult to study, in part because simply identifying these measures is challenging. Against this background, it should be clear that the TRAINS dataset represents a major milestone in the efforts to study NTMs.

In this paper, we argue that the study of NTMs would further benefit immensely from information on how countries enforce the NTMs they impose. Remarkably, this information is not available in a unified and transparent way. Indeed, in many cases this information is not available at all. Finding about and complying with NTMs is likely a significant (hidden) part of the costs created by NTMs.

We also study, in a theoretical model of trade and distribution, the implications of enforcing NTMs in different ways. We find that, whenever possible, countries should



Note: $\alpha = 7, \sigma = 4, \delta = 3$

Figure 3: Sales under NTM relative to frictionless scenario

try to enforce their NTMs in ways that avoid creating per-shipment costs. The rationale for this result is simple: per-shipment costs incentivize firms to change their shipping frequency and inventory decisions. This creates efficiency losses that are not present when the NTMs create fix costs.

Lastly, we carry out a quantitative exercise and show that the enforcing costs of NTMs can be quite significant.

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