Unpacking Non-Tariff Measures: Beyond the Tip of the Iceberg

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Abstract

The effects of non-tariff measures (NTMs) are often summarized as ad-valorem equivalents inferred from their impact on imports. We combine a novel, disaggregated dataset of Indonesian NTMs with transaction-level customs data and plant-level inventory data. Using a dynamic trade model, we map import values, ordering frequency, and inventories into fixed ordering costs, delivery delays, and ad valorem costs. Pre-shipment inspections primarily raise fixed ordering costs, whereas product standards and import authorization requirements raise both fixed costs and delivery delays. In the presence of NTMs, supply disruptions produce more persistent price increases, and temporary tariff shocks have more persistent effects.

Keywords: Non-tariff measures, Trade Costs, Inventory Dynamics, Delivery Delays
JEL: F13, F15

1. Introduction

Rising geopolitical tensions have led to more protectionism and increasing use of non-tariff measures (NTMs), often on political grounds.[1] Recent examples include trade tensions between the United States and China (Fajgelbaum and Khandelwal, 2022), economic sanctions on Russia in response to the invasion of Ukraine (Morgan et al., 2023), and trade restrictions associated with the COVID-19 crisis. In a memorandum on reciprocal trade and tariffs issued on February 13, 2025, the US declared it would impose reciprocal tariffs on trading partners by "*determining the equivalent of a reciprocal tariff,*" taking into account not only taxes and tariffs, but also various types of non-tariff barriers. Yet despite their widespread use and growing policy interest in their costs, little is known about the form in

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[1] See for example Aiyar et al. (2023) and Campos et al. (2023).

which NTMs affect firms. This incidence matters for firms' adjustment behavior and for the propagation of trade shocks.

The standard approach represents trade frictions as multiplicative, or "iceberg," costs, a natural model of ad-valorem tariffs. The NTM literature often follows the same logic by inferring ad-valorem equivalents from reductions in import values (Kee and Nicita, 2022). Many NTMs, however, involve bureaucratic procedures that impose per-shipment costs or delivery delays rather than costs proportional to shipment value. Pre-shipment inspections, for example, can raise the cost of each order, leading firms to place larger, less frequent shipments and adjust their inventory holdings. These responses need not generate a commensurate decline in total imports. Import-based ad-valorem equivalents therefore miss how NTMs affect ordering frequency, inventories, and the dynamics of adjustment.

This paper decomposes individual NTMs into three cost components: fixed ordering costs, delivery delays, and multiplicative costs. We combine their effects on import values, transaction frequency, and inventories with a dynamic trade model that maps these observable responses into underlying frictions. The decomposition allows us to study not only the level effects of NTMs, but also how their design changes the propagation of supply disruptions and tariff shocks. The central implication is that policies with similar ad-valorem equivalents can have very different effects on trade, prices, and the speed of adjustment.

We assemble a novel, hand-collected monthly database of NTMs issued by Indonesian regulatory agencies, covering 2008–2021. We link these measures and tariffs to firm-level monthly customs records at the 10-digit HS level for 2014–2018 and to plant-level manufacturing data on inventories for 2008–2015. This addresses the limited availability of detailed NTM data (Nicita, 2012) and allows us to depart from studies that use aggregate measures (Looi Kee et al., 2009) or broad categories such as sanitary and phytosanitary measures (SPS) and technical barriers to trade (TBT) (Fontagné et al., 2015). Disaggregation is important because measures within the same broad category can operate differently. For example, although both C1 and C3 are classified as inspections, C1 requires inspection at

the port of departure, whereas C3 restricts imports to designated ports in the destination country. Moreover, not all NTMs reduce imports: some measures may credibly signal improved product quality and increase demand (Zavala et al., 2023). Their costs therefore cannot always be inferred from import values alone.

We focus on four NTMs selected using three criteria: they increase import costs; their design or scope is not necessary or proportionate to achieve the stated public policy objective; and they are widely applied. In decreasing order of the share of intermediate imports they affect (Table 1), these are import authorization requirements (coded as B14), pre-shipment inspections (C1), product standards (B7), and port-of-entry restrictions (C3). We estimate their effects on import values, transaction frequency, and firm-level inventories while controlling for tariffs, the number of NTMs in each broad NTM category, and fixed effects.

To translate these reduced-form responses into trade costs, we use a dynamic discrete-choice model based on Alessandria et al. (2010b). Heterogeneous importers face fixed ordering costs, stochastic delivery lags, and multiplicative trade costs. These frictions lead firms to order infrequently and hold inventories. Identification proceeds in two steps. First, we estimate the reduced-form effect of each measure on import values, ordering frequency, and inventory holdings. Second, we simulate the model under variation in each cost component to recover how every moment responds to every cost. The three costs leave distinct signatures in the data: fixed ordering costs primarily reduce ordering frequency, delivery delays raise desired inventories, and ad valorem costs primarily reduce import values. We invert this model-implied mapping to recover the combination of cost changes that reproduces the observed responses to each NTM. Identification therefore relies on the joint response of imports, ordering frequency, and inventories rather than on the decline in imports alone.

The results reveal substantial non-ad-valorem frictions and marked heterogeneity across measures. Pre-shipment inspections have the largest effect on fixed ordering costs, more than tripling them. Import authorization requirements more than double fixed ordering costs, while product standards increase them by approximately 84 percent. Import authorization

requirements also have the largest effect on delivery delays, increasing them by about 25 percent, with product standards generating smaller but significant delays. This finding is consistent with a 2021 World Bank private-sector roundtable in which firms identified the prolonged import authorization process as a major constraint. Port-of-entry restrictions operate primarily through ad valorem costs, raising them by approximately 6 percentage points. An approach based only on import values would therefore assign little cost to product standards and import authorization requirements despite their substantial effects on ordering costs and delays. It would also obscure the difference between pre-shipment inspections and port restrictions, even though both belong to the same broad inspection category. The effects also vary by end use: import authorization requirements raise fixed ordering costs most for capital goods, pre-shipment inspections raise them for both consumption and intermediate goods, and product standards raise fixed costs mainly for intermediate goods but lengthen delays only for consumption goods.

We show that the composition of NTM costs governs the response to trade shocks. Following a temporary increase in delivery times, the high fixed ordering costs associated with pre-shipment inspections induce firms to postpone ordering, producing larger inventory drawdowns, sharper import contractions, higher prices, and slower recovery. By contrast, product standards and import authorization requirements increase firms' steady-state inventory buffers through longer delivery delays. These buffers dampen the initial price response but at an increased cost of maintaining higher levels of steady-state inventories. A similar distinction arises following a tariff shock. High fixed ordering costs slow inventory rebuilding and make the effects on imports and prices more persistent, while policy-induced delivery delays increase firms' reliance on costly inventories, generating smoother dynamic adjustment. NTMs therefore affect not only the level of trade costs but also the timing and persistence of trade adjustment.

Our findings connect micro-level policy design to macroeconomic development. Unreliable input supply and production disruptions are more prevalent in poorer economies

(Brummitt et al., 2017). Such disruptions can contribute to firm-level volatility, which can discourage investment in market access and reduce trade (Merga, 2026). Our results show how NTMs affect firms' responses to supply disruptions through fixed ordering costs, delivery delays, and inventory buffers. These policy measures therefore matter not only for average trade costs but also for robustness and resilience to supply disruptions.

1.1. Related Literature

Our paper is related to two strands of literature. The first studies the importance of different types of trade costs in driving trade flows. Seminal work by Alessandria et al. (2010b) demonstrates that understanding trade flows requires a deeper understanding of the nature of frictions involved in international trade that go beyond affecting only the import values. In particular, fixed ordering costs and delivery delays matter for international trade, leading importers to import infrequently and hold additional inventory. Closely related work combines domestic and foreign input sourcing with inventory adjustment under source-specific ordering costs and delivery-time risk (Novy and Taylor, 2020; Carreras-Valle, forthcoming). General-equilibrium models show how these inventory mechanisms shape aggregate trade and production (Alessandria et al., 2010a, 2013, 2023, 2025). In a model with international production networks, He and Liu (2024) show how inventories buffer the transmission of shocks across sectors and countries. Our partial-equilibrium framework isolates the ordering and inventory margins. Responses along these margins identify the effects of NTMs on different components of trade costs. More broadly, our emphasis on dynamic firm-level adjustment margins is related to Roberts and Tybout (1997) and Das et al. (2007), who show that sunk entry costs, prior market experience, and firm heterogeneity shape export participation and aggregate trade responses. Ruhl and Willis (2017) further show that accounting for new exporters' growth and survival substantially changes the inferred costs of export entry, highlighting the importance of firm-level dynamics for identifying trade frictions. We study analogous dynamic adjustment frictions on the import side, where NTMs affect not only the level of trade but also ordering frequency and inventory buffers. In contrast, as

discussed in Hummels and Schaur (2010), most of the literature has converted frictions such as time-to-trade into ad-valorem cost equivalents or has only looked at the impact of frictions on import values (Djankov et al., 2010; Clark et al., 2014; Feyrer, 2019; Feyrer, 2021). A body of literature leverages transaction-level data to infer trade costs (Kropf and Sauré, 2014; Hornok and Koren, 2015) or utilizes direct information on shipping costs and modeling approaches, combined with standard customs data, to estimate the additive component of trade costs (Irarrazabal et al., 2015; Hummels and Skiba, 2004). We contribute to this literature by estimating the effect of non-tariff policy measures on different aspects of trade costs that go beyond the import values. Our novel identification strategy combines the relationship between moments (inventory holdings, frequency of transactions, and import values) and NTMs in the data with model-implied elasticities of moments with respect to costs to decompose the effect of different types of NTMs on unobserved non-tariff cost equivalents.

This relates our work to the second strand of literature that estimates the impacts of non-tariff measures on imports.[2] In general, the literature obtains negative impacts of NTMs on imports, either by relying on measures of NTMs as regressors in a gravity equation of trade (Looi Kee et al., 2009; Disdier et al., 2023) or estimating the trade-impeding effects of NTMs from smaller than predicted trade flows (Chen et al., 2022; Cadot and Gourdon, 2016). Most studies classify NTMs into different broad groups (such as SPS, TBT) or rely on a cross-section of products subject to different NTMs at a fixed point in time.[3] These reduced import values due to NTMs are then converted to ad-valorem equivalent measures to quantify the costs of NTMs (Kee and Nicita, 2022). We contribute to the literature in three ways: First, we show that not all NTMs affect import values, and thus will not be reflected in ad-valorem costs. These measures can operate through adjustment margins that need not be fully reflected in import values. Second, we show that different types of NTMs within the

[2]See Ederington and Ruta (2016) for a survey of the literature.

[3]Bao and Qiu (2012) use a panel of NTM data but focus on TBT notifications to the WTO, which suffer from the caveat that they are often incomplete as countries' governments are not always informed of the requirement to notify the WTO (Ederington and Ruta, 2016).

same broad grouped measure like SPS, TBT, or INSP can have very different effects. For example, even though pre-shipment inspections and port-of-entry restrictions are both INSP measures, these have very different effects on import values. Finally, the quantification of the effects of NTMs on costs is possible by using data on the panel of all non-tariff measures in Indonesia, which allows us to relate changes in non-tariff measures over time to imports, controlling for unobserved product heterogeneity.

The paper proceeds in the following way: Section 2 describes the data sources and the choice of NTMs. Section 3 details the model and identification strategy. Section 4 presents the baseline empirical results. Sections 5 and 6 report the model-based decomposition and show how NTMs shape the dynamic response of firms to trade shocks. Section 7 studies heterogeneity by end-use category. Section 8 concludes.

2. Data and Institutional Setting

We combine three data sources. The first consists of monthly customs records covering the universe of Indonesian importers. The second is the Annual Manufacturing Survey of plants with at least 20 employees. The third is a novel, time-varying product-level panel of NTMs assembled by the World Bank. The NTM panel varies monthly at the 10-digit HS and 3-digit MAST levels.

2.1. Customs trade data

For the trade data, we use customs-level monthly data covering the universe of Indonesian importers from 2014 to 2018. Product-level monthly import values for earlier years (2008–2013) are used only to construct the pre-period weights described in Section 4. The import data spans the full spectrum of Indonesian imports in the same period, excluding oil imports. It accounts for around 80% of total imports between 2014 and 2018 and represents the import activities of 36,895 firms. One appealing feature of this dataset is its high level of disaggregation (10-digit HS code). The dataset contains monthly dollar values and quantities

of imports at the firm-year-month-HS-10 product level, along with information on the country of origin.

2.2. Plant-level manufacturing data

Plant-level data are taken from the Indonesian survey of manufacturing plants with at least 20 employees (Statistik Industri, SI) administered by the Indonesian Statistical Office (BPS), utilized and described in great detail in Calì et al. (2024). The coverage of the survey is extensive; in fact, it becomes an actual census in 1996 and 2006 and it is very close to a census in the remaining years, hence ensuring high representativeness even at the provincial level. Plants are grouped into five-digit industries following the definition in the Klasifikasi Baku Lapangan Usaha Indonesia (KBLI), a classification mostly compatible with ISIC coding. Our data include information on quantities and values of the products produced, raw inputs (domestic and imported), as well as the level of inventory for each plant. These are both defined at a highly granular level, namely nine digits Klasifikasi Komoditi Indonesia (KKI), a more detailed classification based on KBLI. In our sample, each plant produces on average two products and 25% of the plants produce more than one product. On average, each plant uses four different varieties of raw inputs. A unique feature of the manufacturing dataset is its plant-level inventory information, which allows us to study how firms adjust to NTMs along a broader set of margins than the import outcomes typically considered in the literature. Our inventory sample covers 2008–2015. For our regressions, we divide inventories by total annual raw-material purchases and trim the resulting inventory-purchase ratio at the 5^{th} and 95^{th} percentiles, dropping observations outside this range. Because the survey unit is the plant, "firm" in the inventory analysis refers to a plant.[4]

2.3. Product-level NTMs and tariffs

During 2014–2018, NTM-related regulations in Indonesia were issued by 13 government institutions, including ministries and agencies; some regulations were also issued by presi-

[4]In a typical year, a median firm holds 3.6 months' worth of purchases in inventories.

dential decree. Each institution has its own mandate. This makes monitoring NTMs difficult since no dedicated government institution can carry out NTM regulatory review and stock-taking (Munadi, 2019).

To overcome these issues, we use a novel comprehensive NTM database built by the World Bank based on data collected by the Economic Research Institute for ASEAN and East Asia (ERIA) in collaboration with UNCTAD (Montfaucon et al., 2023). The UNCTAD/ERIA dataset identifies the stock of NTMs applied by Indonesia as of 2015. The dataset is cleaned extensively to address coding and interpretation errors and made time-varying by tracking the individual NTMs applied to each product before and after 2015.[5] The dataset uses the most disaggregated NTM classification available, i.e., 3-digit MAST level. This classification is the most appropriate for policy analysis as it identifies individual measures introduced or modified by each agency. A total of over 60 3-digit NTMs are available in the dataset, each with values coded between 0 and 1 to signify when they were in effect; that is, the dataset varies at the month-product pair. As opposed to very aggregated NTM measures such as SPS or TBT, we have information at the granular individual NTM level, which allows us to study the effects of specific NTMs, as detailed in the next subsection.

In addition, we complete the trade policy data with import tariff data collected by the UNCTAD Trade Analysis Information System (TRAINS) dataset. For Indonesia, these data include annual Most Favored Nations (MFN) applied import tariff at the HS 10-digit product level.[6]

2.3.1. Selecting NTMs for analysis

Table 1 contains the list of NTMs that affect at least 10% of products at the 8-digit HS level during 2008–2021. We rank the NTMs by the share of value of intermediate products

[5]ERIA has updated the data and the latest one is 2018, where some of these coding errors may have been addressed. Calì and Montfaucon (2021) detail the process, dissimilarities, and coding errors corrected in the data. Additionally, Montfaucon et al. (2023) also provide more details on the construction of the data and the institutional context.

[6]Because the product-level customs regressions exclude FTA partners, MFN rates provide the relevant common tariff schedule for the origin countries retained in the sample.

that they affect, which range from 6% to 38%. We focus on four of these ten NTMs using the selection procedure developed in earlier work (Calì et al., 2026, 2024). This procedure identifies measures that are protectionist in their design and application based on three criteria: (i) they increase import costs; (ii) their design or scope is not necessary or proportionate to achieve the stated public-policy objective; and (iii) they are widely applied. On the basis of these criteria, we are able to identify four distinct NTM measures. These include product standards (B7 in UNCTAD's MAST classification), import authorization requirements (B14), pre-shipment inspections (C1), and port-of-entry restrictions (C3). Figure 1 shows the incidence of these NTMs on firms in Indonesia. Panel A shows the share of all importing firms affected by each NTM. More than half of all importing firms in this time period faced import authorization requirements (B14) and pre-shipment inspections (C1). Between 28% and 40% of firms faced product standards (B7), while between 19% and 35% of firms faced port-of-entry restrictions (C3). The coverage ratio, the share of imports subject to each NTM, separates the measures into the same two groups: between 26% and 34% of imports are subject to B14 and between 29% and 32% to C1, compared with 12–14% for B7 and 12–18% for C3.

Table 1: Top NTMs affecting the value of Intermediate Products in Indonesia 2008-2021

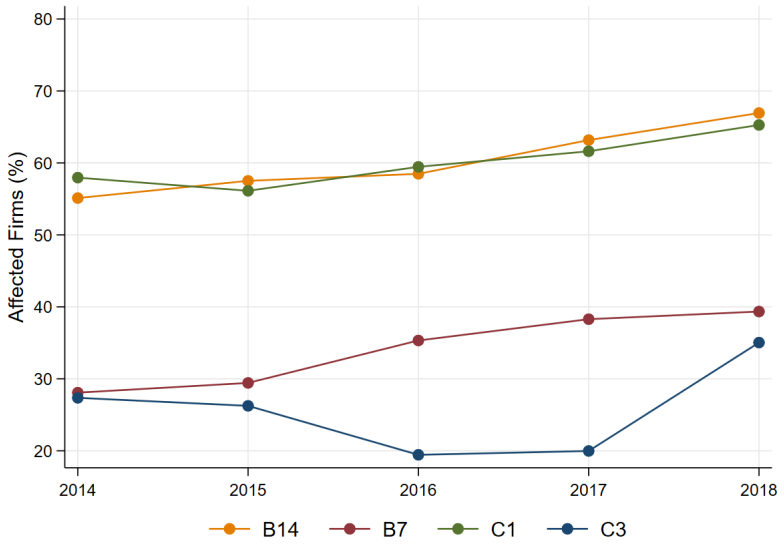
	Intermediate
B15 Authorization requirements for importers	38%
B85 Traceability requirements	32%
B14 Authorization requirements for importing certain products	28%
C1 Pre-shipment inspection	22%
B31 Labelling requirements	12%
B7 Product quality, safety or performance requirements	11%
C3 Requirement to pass through specified port of customs	9%
B82 Testing requirement	8%
B83 Certification requirement	7%
B81 Product registration requirement	6%

Notes: The table lists the share of the value of intermediate goods that is subject to NTMs.

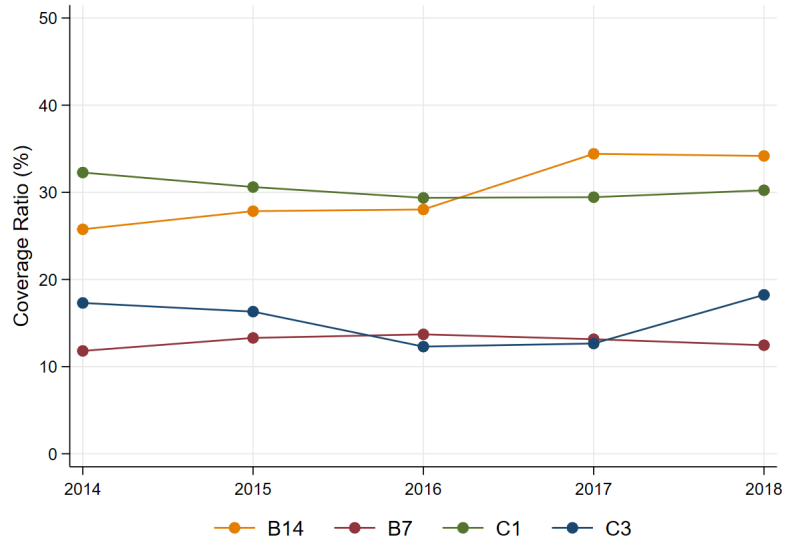
As NTMs are heterogeneous in their application and cost implications, it is necessary to

Figure 1: **Share of total imports and percentage of firms affected by NTMs**

(a) Share of Importing Firms



(b) Import Coverage Ratio



Notes: Panel (a) plots the share of importing firms affected by the four different NTMs under study. Panel (b) plots the coverage ratio (share of total imports affected by an NTM) for the four different NTMs under study. Source of data is Indonesian firm-level customs data from 2014 to 2018 and the time-varying NTM dataset compiled by the World Bank Jakarta Office.

use highly disaggregated levels of NTMs. At the same time, we control for the broader NTM regime that a product faces, using counts of the measures in broad NTM categories such as SPS and TBT.

Product Standards. The first NTM is *product standards* (B7), the requirement to comply with Indonesian national standards (SNI), which countries typically require to ensure the safety of the users of the goods. In Indonesia, this is mandatory for a wide range of manufacturing goods. As certification requires a visit to the factory premises by an Indonesian certifying agency, the cost is considerably higher for imported goods. The monetary cost is compounded by the lengthy duration of the process. In addition, a lack of harmonization with international standards could also limit exports for Indonesia for more products with a global standard (e.g., medical equipment). Renewing SNI can also be unpredictable and lacks transparency.

Import Authorization Requirements. The second measure is *import authorization requirements* (B14). The Ministry of Trade issues this, with specific supporting recommendations from related ministries, before the product can be imported. These letters aim to fulfill non-trade objectives, which are often related to the protection of domestic producers in the sector. Ministries have relatively high discretion in deciding on the recommendation, including whether or not to grant it, how long it takes for them to respond, and the quantity allowed for the specific approval, which can differ from what the producer requested. When the import authorization aims to protect producers, this NTM does not seem to comply with the WTO principle that "any person fulfilling the legal requirements should be equally eligible to apply for and obtain import licenses" (WTO GATT, Article 2.1).

Pre-Shipment Inspections. The third measure, *pre-shipment inspections* (C1), requires shipments to be inspected at the port of departure from the exporting country before leaving for Indonesia. The objective of pre-shipment inspection is to ensure that the import declaration lists the correct classification of the goods to be imported as a way of detecting

improper importing activities. A surveyor report outlining the surveyor firm's inspection results is a documentary requirement for certain goods. In Indonesia, only two State-Owned Enterprises (SOEs) have the authority (granted by the Ministry of Trade) to perform pre-shipment inspections for the Indonesian government. Beyond the service fees, the cumbersome compliance process can increase import costs by lengthening import times and raising compliance costs. The SOEs at times further outsource the inspection to other companies. Anecdotal evidence - gathered from interviewing companies in Indonesia - suggests that such a limited supply of inspection agencies further increases the time it takes to comply with such a procedure.[7]

This measure is not only costly to comply with, but it also appears redundant in a country like Indonesia, where the customs agency applies a risk management system aimed at detecting suspicious shipments at the border.[8] As further evidence that this measure appears unnecessary, we find that Indonesia is the only country in Southeast Asia—and among the middle-income countries in our comparison—that requires pre-shipment inspections.

Port-of-Entry Restrictions. Our final measure is related to the obligation that certain imported goods must enter Indonesia through designated ports (C3), i.e., *port-of-entry restrictions*. This requirement is intended to ensure the safety of imported products by directing imports to ports that possess adequate screening facilities. However, this raises trade costs and increases prices in product markets, as goods are not able to enter through their natural entry port according to market demand. This measure is applied to less than 6% of imports in the rest of Southeast Asia, compared to 12–18% in Indonesia over 2014–2018 (Figure 1).

The persistence of these measures despite the trade costs they impose reflects both their stated regulatory objectives and political-economy considerations. Pre-shipment inspections

[7]Consistent with this evidence, Calì and Montfaucon (2021) find that a 1% increase in exposure to pre-shipment inspections leads to a 0.6% drop in export values in Indonesia.

[8]Indeed, our interviews with Indonesian officials suggest that the customs agency does not take the pre-shipment inspection report into account in their assessment of the risk of the shipment.

are intended to prevent misclassification and other improper importing practices; port-of-entry restrictions concentrate imports at locations with adequate screening facilities; and product standards seek to safeguard product quality and safety. These objectives do not, however, imply that the observed design and breadth of each measure are necessary or proportionate. As discussed above, pre-shipment inspections duplicate customs risk management, port restrictions divert goods from their natural entry points, and mandatory certification applies to many intermediate inputs with limited consumer-safety risks. Import authorization requirements are more directly connected to protecting domestic producers because sectoral ministries retain discretion over whether and when an approval is issued and the quantity authorized. More broadly, these measures fit a pattern in which Indonesia's tariff liberalization has been accompanied by rising use of administrative trade restrictions and explicit import-substitution objectives (Calì et al., 2026; World Bank, 2022).

3. Dynamic Model with Inventories and Lumpy Trade

In this section, we introduce a partial equilibrium discrete-choice model with heterogeneous firms facing international transaction frictions that lead them to hold inventories. The purpose of the model is to provide information about how the fixed order cost, shipping delays, and ad valorem trade costs affect the import values, shipping frequency, and inventory holdings. By providing a link between parameters and the moments, the model bridges the gap between NTMs and the cost parameters. This model builds on the framework in Alessandria et al. (2010b), with the added element of stochastic delivery.

In the model, retail firms order imported inputs to sell at home subject to delivery delays, fixed ordering costs, and variable costs. Unsold goods can be saved in inventory to be sold in future periods, but they incur a holding cost that depends on the interest rate and a depreciation rate. These holding costs keep firms from holding too many goods in inventory. The firm pays a fixed cost for each shipment of goods, which gives firms an incentive to order infrequently and hold more goods in inventory. Firms face idiosyncratic demand shocks for

their varieties, so their sales in each period are uncertain and goods do not always arrive in the period they are ordered. In contrast to standard trade frameworks, fixed ordering costs and delivery lags, together with their relationship to observed ordering frequency and inventory holdings, make the model particularly well suited to estimating the broader effects of NTMs.

3.1. Firm Problem

There is a unit mass of firms that sell differentiated products. Firm j faces idiosyncratic demand (ν_j) and holds inventories (s_j). In each period, the firm decides how much input, z_j, to order and what price, p_j, to charge for the differentiated variety. The importer's demand, y_j, is a function of price with a constant elasticity of substitution: $y_j = e_j^{\nu} p_j^{-\theta}$, where ν is drawn from a normal distribution with variance σ_ν, $N(0, \sigma_\nu)$.[9]

Goods ordered at the beginning of the period arrive within the same period with probability $1 - \mu_I$. With probability μ_I the goods are delayed and arrive in the next period. The timing is as follows: firms observe their demand and place their input orders, they observe whether the inputs arrive in the current period, and finally, they set prices. Firms pay a fixed cost ϕ_I if they order a positive quantity of inputs. Thus, firms have an incentive to order less frequently and save inputs in inventories to meet demand. Inventories depreciate at rate δ. Goods that were ordered but not delivered in the current period also depreciate at the same rate in transit.

A firm's sales are limited by the stock of goods on hand, so total sales are restricted to sales of inventories and any goods that arrive in the current period. If demand exceeds this value, the firm sells all of its goods on hand and carries zero inventories into the next period.[10] Ending-period inventories are carried over to the next period net of depreciation.

[9]The elasticity θ summarizes substitution between the affected imported variety and domestic or other foreign alternatives. A multiple-input production model would add explicit source reallocation, while leaving the ordering and inventory problem for each imported input unchanged.

[10]In practice, firms may respond to stockouts through posted price changes, rationing, or delayed fulfillment. The model summarizes these margins through the shadow value of available inventories, which maps into the retail price response in the simulations.

In the following section, we present the problem of retailers. Given the firm's beginning-of-period inventory and its demand shock ν, the firm's value is

$$V(s,\nu) = \max\left\{V^N(s,\nu), J(s,\nu) - \phi_I\right\}, \tag{1}$$

where V^N is the value of the firm that does not place an order for inputs and $J(s,\nu)$ is the gross value of the firm if it places an order for inputs. If the firm places an order, it pays the fixed cost ϕ_I.

If the firm does not place an order, it chooses its price and quantities to sell to the manufacturing and consumption-good firms. These quantities are constrained by the inventories on hand,

$$V^N(s,\nu) = \max_p \; p\, q(p,s,\nu) + (1+R)^{-1} \mathop{\mathbb{E}}_{\nu'} V(s',\nu') \tag{2}$$

$$\text{s.t.} \;\; q(p,s,\nu) = \min(e^{\nu} p^{-\theta}, s) \tag{3}$$

$$s' = (1-\delta)\left[s - q(p,s,\nu)\right] \tag{4}$$

If the firm places an order, either the inputs arrive in the current period or the next. If the inputs did not arrive in the current period, the value of the firm is

$$V^O(s,\nu,z) = \max_p \; p\, q(p,s,\nu) + (1+R)^{-1} \mathop{\mathbb{E}}_{\nu'} V(s',\nu') \tag{5}$$

$$\text{s.t.} \;\; q(p,s,\nu) = \min(e^{\nu} p^{-\theta}, s) \tag{6}$$

$$s' = (1-\delta)\left[s + z - q(p,s,\nu)\right] \tag{7}$$

where the difference between the two problems appears in the equation of motion of inventories. Notice that the inputs (z) do not appear in the stockout constraint (6) and deterministically arrive in the next period. If the inputs arrive in the current period, the firm's value is the same as that defined in (2) except that its available inventories are $s + z$.

The value of the firm when it places an order is

$$J(s,\nu) = \max_{z} \; -\iota\,\omega\,z + (1-\mu)V^N(s+z,\nu) + \mu V^O(s,\nu,z) \tag{8}$$

where ω is the purchase price of imports and ι denotes the ad-valorem cost of imports. The solution to these problems takes the form of an "sS rule," where firms place orders when inventories have fallen to low enough levels. Conditional on reordering, the firm sets the expected marginal value of a unit of inventory in the next period to the marginal price of the input

$$(1+R)^{-1}(1-\delta)\,\underset{\nu'}{\mathbb{E}}\,V_1\left(s',\nu'\right) = \iota\,\omega, \tag{9}$$

where V_1 is the derivative of the value function with respect to the inventory level. When the stockout constraint (6) does not bind, monopolistic competition implies the usual constant-markup pricing rule:

$$p(s,\nu) = \frac{\theta}{\theta-1}(1+R)^{-1}(1-\delta)\,\underset{\nu'}{\mathbb{E}}\,V_1\left(s',\nu'\right). \tag{10}$$

Notice that the markup is over the opportunity cost of a unit of inventories. If the firm makes a sale today, it begins the next period with fewer inventories. Only when the firm orders and the shipment arrives in the current period is the price a markup over ω.

For tractability, the model has a single inventory stock, s. This stock should be interpreted as a costly buffer that allows firms to separate the timing of purchases from the timing of sales or production. In the data, this buffer can appear as raw-material inventories, goods in process, or finished-goods inventories, depending on the firm's technology, production lags, and position in the supply chain. We abstract from these within-firm time-to-build and accounting distinctions because the key margin for our decomposition is the stockpiling response to ordering costs and delivery delays: firms facing demand shocks and uncertain arrivals hold inventories to smooth sales and production. A model with inventories at multiple

production stages would redistribute this buffer across inventory types, but would leave the central mechanism—that NTMs affect stockholding and ordering behavior—unchanged.[11]

3.2. Identifying cost parameters

We identify the effects of NTMs on fixed ordering costs, shipping delays, and ad-valorem costs by combining their reduced-form effects on inventories, ordering frequency, and imports with the model-implied mapping from these moments to the three cost parameters. The first mapping relates NTMs to the costs faced by importers:

$$\ln \phi_I = a_\phi + \ln \phi_D + \beta_{\phi,1} NTM_1 + \beta_{\phi,2} NTM_2 + \beta_{\phi,3} NTM_3 + \beta_{\phi,4} NTM_4 \tag{11a}$$

$$\ln \mu_I = a_\mu + \ln \mu_D + \beta_{\mu,1} NTM_1 + \beta_{\mu,2} NTM_2 + \beta_{\mu,3} NTM_3 + \beta_{\mu,4} NTM_4 \tag{11b}$$

$$\ln \iota_I = a_\iota + \ln \iota_D + \beta_{\iota,1} NTM_1 + \beta_{\iota,2} NTM_2 + \beta_{\iota,3} NTM_3 + \beta_{\iota,4} NTM_4 \tag{11c}$$

where $\beta_{i,j}$ denotes the effect of NTM j on cost component $i \in \{\phi, \mu, \iota\}$. The corresponding cost faced by domestic producers is denoted by i_D, while a_i captures the NTM-independent cost differential between importers and domestic producers.[12] In matrix notation,

$$COST_I = \mathbf{A} + COST_D + \beta NTM \tag{12}$$

From the model, we also know that the cost parameters mainly affect inventory holdings (S_I), frequency of ordering (F_I), and the import level (Z_I). We therefore formulate the data

[11] Online Appendix Table B.2 supports this interpretation by showing similar coefficient signs when finished-goods inventories replace the baseline outcome.

[12] For example, tariffs are captured by a_i.

relationship of average moments as a function of cost parameters,

$$\ln S_I = \gamma_{S,\phi} \ln \phi_I + \gamma_{S,\mu} \ln \mu_I + \gamma_{S,\iota} \ln \iota \tag{13a}$$

$$\ln F_I = \gamma_{F,\phi} \ln \phi_I + \gamma_{F,\mu} \ln \mu_I + \gamma_{F,\iota} \ln \iota \tag{13b}$$

$$\ln Z_I = \gamma_{Z,\phi} \ln \phi_I + \gamma_{Z,\mu} \ln \mu_I + \gamma_{Z,\iota} \ln \iota \tag{13c}$$

In matrix form, this can be written as

$$Moments_I = \Gamma COST_I \tag{14}$$

Since we observe moments and NTMs in the data, we substitute (12) into (14) to arrive at:

$$Moments_I = \Gamma \mathbf{A} + \Gamma COST_D + \Xi NTM \tag{15}$$

where $\Xi = \Gamma\beta$. The matrix Γ is 3×3, because it maps the three cost parameters into the three moments, while Ξ and β contain one column for each NTM. Thus, the inversion requires Γ to have full rank but does not require the number of NTMs to equal the number of moments.[13] These equations can be written as:

$$\ln S_I = \xi_{S,1} NTM_1 + \xi_{S,2} NTM_2 + \xi_{S,3} NTM_3 + \xi_{S,4} NTM_4 + \kappa_S \tag{16a}$$

$$\ln F_I = \xi_{F,1} NTM_1 + \xi_{F,2} NTM_2 + \xi_{F,3} NTM_3 + \xi_{F,4} NTM_4 + \kappa_F \tag{16b}$$

$$\ln Z_I = \xi_{Z,1} NTM_1 + \xi_{Z,2} NTM_2 + \xi_{Z,3} NTM_3 + \xi_{Z,4} NTM_4 + \kappa_Z \tag{16c}$$

In Section 4, we estimate the matrix Ξ using the product- and firm-level data, where we also discuss the identifying variation and assumptions alongside each empirical specification.

[13] Economically, the full-rank condition means that the three cost components must produce sufficiently distinct patterns across inventories, ordering frequency, and imports.

We then use the relationship between parameters and these moments in the model (Γ) to obtain β in Section 5. We later use this estimated relationship between the parameter values and NTMs (β matrix) to perform counterfactual exercises with different NTMs.

A practical advantage of this indirect-inference approach is that the dynamic model needs to be solved only to recover the mapping Γ between cost parameters and observable moments. Once this mapping is obtained, the researcher can study additional NTMs, alternative NTM groupings, or heterogeneous effects across product and firm categories by estimating the corresponding reduced-form moment vector Ξ and applying the inversion, $\beta = \Gamma^{-1}\Xi$.[14] This modular structure makes the decomposition transparent and scalable: it preserves the economic discipline of the dynamic model without requiring a separate high-dimensional nonlinear estimation for every set of NTMs or subsample. Online Appendix C evaluates the sensitivity of the decomposition to alternative structural parameters, and the main qualitative ranking of NTM cost channels remains stable.

4. Empirical Results: Effects of NTMs

In this section, we study the effects of NTMs on import values, ordering frequency, and inventories. Where possible, we conduct a product level analysis since NTMs are imposed on products.[15] We restrict the customs sample to non-FTA origins because preferential partners may face a different effective regulatory regime. Deep trade agreements can reduce NTM-related compliance costs through harmonized standards, mutual recognition of conformity-assessment results, and customs cooperation (Cadot and Gourdon, 2016; Fernandes et al.,

[14] A direct method-of-simulated-moments estimator could instead substitute the policy–cost mapping into the model and jointly target the same moments. In the exactly identified log-linear case with the same moments, it is algebraically equivalent to the inversion used here. We retain the two-step implementation because it separates the reduced-form estimates in Ξ from the model-implied mapping in Γ and allows the same simulated mapping to be reused across NTMs and subsamples. Conditional on Γ, the clustered sampling uncertainty in Ξ can be propagated through this linear transformation; Online Appendix C separately reports the sensitivity of the decomposition to alternative calibrations of Γ.

[15] The information on import values and ordering frequency comes from the customs data, which can be aggregated to the product level. The information on inventories comes from plant-level manufacturing survey data, which cannot be aggregated to the product level.

2021).

4.1. Effect of NTMs on Import Values and Ordering Frequency

We begin by exploring the effects of these four NTMs on annual import values and ordering frequencies, controlling for tariffs and for the number of NTMs in each broad NTM category.

$$\begin{aligned}\ln Y_{gt} =& \xi_{Y,1} d_{B7,gt} + \xi_{Y,2} d_{B14,gt} + \xi_{Y,3} d_{C1,gt} \\ &+ \xi_{Y,4} d_{C3,gt} + \zeta_Y \tau_{gt} + \Theta_Y X_{gt} + \zeta_{g4} + \zeta_{g2,t} + \epsilon_{gt}\end{aligned} \tag{17}$$

where Y_{gt} denotes either the import value or the number of transactions of HS6-level product g in the year t. This is the data counterpart to the equations (16b) and (16c). The NTM exposure variable $d_{j,gt}$ denotes the simple average share of HS10 products within the HS6 category g that are subject to NTM j in year t. Import value is the total USD value of imports of a particular good g, while the number of transactions is the number of times (months) an Indonesian firm transacts good g, summed up across all firms. The tariff on product g in year t is denoted by τ_{gt}. X_{gt} denotes the vector of NTM category counts: the number of measures in the SPS, TBT, quantity-control, price-control, and export-measure chapters. In the transactions regression, the controls also include ln(imports) of product g in year t, so that $\xi_{F,j}$ measures the effect on ordering frequency holding the import value fixed.

In terms of notation described in Section 3.2, $\Xi = \Gamma\beta$, where Ξ is the matrix containing the ξ coefficients from all three data regressions. We also include HS 4-digit and HS2-year fixed effects, denoted above by ζ_{g4} and $\zeta_{g2,t}$ respectively. The HS-4 digit fixed effects absorb time-invariant differences across product categories (such as baseline demand, production technologies). The HS2-year fixed effects control for time-varying shocks common to broader product sectors, including sector-specific demand fluctuations, global price movements, and sector-wide policy changes. The coefficients are therefore identified from differential changes

in NTM exposure across HS6 products within the same HS2-by-year, after absorbing time-invariant differences across HS4 categories. Identification requires that—conditional on these fixed effects, tariffs, and the NTM category counts—changes in a given NTM be uncorrelated with product-specific shocks to imports or transaction frequency.

The first two columns in Table 2 present the results. NTMs mostly have a negative effect on import values and the number of transactions, but at varying economic and statistical intensities. While B7 (product standards) and B14 (import authorization requirements) do not seem to affect imports significantly, C1 (pre-shipment inspections) and C3 (port-of-entry restrictions) significantly reduce imports by 0.35 and 0.45 log points, respectively. On the other hand, B7, B14, and C1 primarily affect the number of transactions, reducing it by 0.26, 0.34 and 0.68 log points (column 2), respectively. These results are robust to alternative specifications, namely omitting the tariff control and using pre-analysis-period (2010–2013) weights when aggregating NTMs from the HS10 to the HS6 level (Online Appendix Table B.1).

4.2. Effect of NTMs on Firm Inventories

Next, we estimate the effect of NTMs on inventory holdings. Unlike the product-level analysis of import values and transaction frequency, the inventory analysis is conducted at the firm level because inventories are not observed at the product level.

We begin by summarizing the monthly binary NTM variables at the annual level using monthly imports as the weight:

$$NTM_{gt} = \sum_{m=1}^{12} \frac{Z_{gtm}}{Z_{gt}} NTM_{gtm} \tag{18}$$

where NTM_{gtm} is the binary variable assuming the value 1 if the NTM is in place for the product g in month m of year t. We use monthly import values as weights, computed as the ratio of Z_{gtm} (monthly imports of product g) and Z_{gt} (yearly imports of product g).

We then bring the NTM exposure from the product level to the firm level. It is important to note that we are interested in the NTMs faced by firms' inputs. Therefore, we use the

Table 2: Reduced-Form Effects of NTMs on Imports, Transaction Frequency, and Inventories

Dep. var.	ln(imports)	ln(#transactions)	ln (Inventory/Purchases)
	(1)	(2)	(3)
d_{B7} (Product Standards)	-0.01	-0.26***	0.22**
	(0.28)	(0.09)	(0.11)
d_{B14} (Import Authorization Req.)	-0.02	-0.34***	0.30*
	(0.19)	(0.07)	(0.18)
d_{C1} (Pre-Shipment Insp.)	-0.35*	-0.68***	0.06
	(0.21)	(0.08)	(0.13)
d_{C3} (Port-of-Entry Req.)	-0.45**	0.13	-0.08
	(0.22)	(0.08)	(0.06)
Tariff	-7.27***	0.41	-0.00
	(1.46)	(0.60)	(0.01)
ln (imports)		0.44***	
		(0.01)	
NTM category counts	✓	✓	✓
HS4 FE	✓	✓	
HS2-Year FE	✓	✓	
Year FE			✓
Firm FE			✓
N	17,505	17,505	85,945
R^2	0.55	0.85	0.79

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table reports estimates of the effect of NTMs on annual import values (col. 1), the number of import transactions (col. 2), and inventory holdings relative to purchases (col. 3). Columns 1–2 use a product (HS6) × year panel of total imports into Indonesia, 2014–2018. The NTM regressors ($d_{j,gt}$) are product-level NTM exposure measures representing the share of HS10 products within the HS6 category that are subject to NTM j in a given year. Both columns include HS4 fixed effects and HS2×year fixed effects. Additional controls include tariff exposure and normalized NTM intensity shares for TBT, SPS, quantity-control, price-control, and export measures (*NTM category counts*). Column 2 additionally controls for ln(imports). Standard errors are clustered at the HS6 level. Column 3 uses a firm × year panel from the Annual Manufacturing Survey, 2008–2015. The specification includes firm and year fixed effects. Additional controls include ln(raw materials), ln(sales), an IO-weighted tariff, and NTM intensity counts for SPS, TBT, quantity-control, and price-control measures (*NTM category counts*). Standard errors are clustered at the firm level.

input-output tables to construct an input-share weighted exposure of NTMs. We do this in a few steps. First, we merge product-level NTMs to the 5-digit KBLI code of the industry of the firm in the survey of manufacturing plants, described in Section 2.2, using a concordance between HS6 codes and KBLI industry codes.

Second, we add the coarser input-output (IO) codes to the plant-level data since the input-output information is available at the IO code level.[16] Then we use the cross-industry purchases in 2016 as the weights to construct a measure of NTMs on firms' inputs using:

$$NTM_{st}^{in} = \sum_{r} \omega_{sr,2016} NTM_{rt}^{out} \tag{19}$$

where $\omega_{sr,y}$ is industry r's share in total purchases of industry s in year y and NTM_{rt}^{out} is the NTM incidence on IO industry r in year t, again constructed using import weights to aggregate HS-level NTMs to IO-code level. After constructing the relevant independent variables, we run the following specification which is the data counterpart of (16a):

$$\begin{aligned} \ln S_{ft} =& \xi_{S,1} B7_{s(f)t}^{in} + \xi_{S,2} B14_{s(f)t}^{in} + \xi_{S,3} C1_{s(f)t}^{in} \\ &+ \xi_{S,4} C3_{s(f)t}^{in} + \zeta_S \tau_{s(f)t}^{in} + \Theta_S X_{s(f)t} + \Lambda W_{ft} + \zeta_f + \zeta_t + \varepsilon_{ft} \end{aligned} \tag{20}$$

where S_{ft} is the ratio of end-of-year raw-material and semi-finished inventories to total raw-material purchases for firm f. The vector W_{ft} contains ln(raw-material purchases) and ln(sales) of firm f in year t. The variable $NTM_{s(f)t}$ denotes the weighted average incidence of a particular NTM on IO industry s of the firm f, with $NTM \in \{B7, B14, C1, C3\}$. $\tau_{s(f)t}^{in}$ is the input tariff on IO industry s of firm f in year t, obtained through the same weighting process defined above for the NTMs. $X_{s(f)t}$ denotes counts of SPS, TBT, quantity-control, and price-control measures, weighted in the same way. We also control for firm and year fixed effects, shown above as ζ_f and ζ_t, respectively. Identification requires that, conditional

[16] The change in the aggregation level is such that we go from 278 KBLI industries to 73 input-output industries.

on tariffs and the NTM category counts, these changes be uncorrelated with firm-specific shocks to inventory holdings.

The estimation results are detailed in the last column of Table 2. The analysis reveals that two out of the four NTMs — product standards (B7) and import authorization requirements (B14)— significantly and positively impact inventories, with import authorization requirements exerting the largest effect. Conversely, the pre-shipment inspection (C1) and port-of-entry requirement (C3) do not significantly affect inventories. These findings suggest that the first two NTMs contribute to delivery delays, prompting firms to maintain higher inventory levels as a buffer.[17] Because inventories are not reported separately by source, these coefficients capture the net inventory response after any substitution toward domestic inputs or alternative foreign suppliers. Any domestic substitution would attenuate, rather than mechanically generate, the estimated stockpiling response because internationally sourced inputs are more inventory-intensive than domestically sourced inputs (Nadais, 2017; Khan and Khederlarian, 2025).

Our baseline inventory outcome uses raw-material and semi-finished goods inventories because these are the inventory categories most directly linked to imported input availability. The manufacturing survey also reports finished-goods inventories. Finished goods account for roughly one-quarter to one-third of total inventories in our data, indicating that firms hold buffers at multiple stages of the production and sales process. This distinction is useful for interpreting the data but is not central to the mechanism we emphasize. When NTMs create delivery delays, firms facing demand shocks may respond by holding additional raw materials, semi-finished goods, or finished goods. Which inventory category absorbs the shock depends on production technology and time-to-build considerations that we abstract from in the model. What matters for our identification is the stockpiling margin itself: NTMs that increase delivery delays raise the value of carrying inventories as a buffer. The

[17]Online Appendix Table A.1 shows that the inventory responses of the largest firms and of other firms do not differ significantly for B7, B14, and C1.

positive effects of B7 and B14 on raw-material and semi-finished inventories therefore provide direct evidence of upstream precautionary stockpiling in response to NTM-induced timing frictions.[18]

5. Model Quantification

We now discuss model calibration, data results, and the decomposition of the NTMs into different cost components following the methodology described in Section 3.2.

5.1. Calibration

To obtain the relationship between model parameters and the moments, we simulate the model for a wide range of parameters and run regressions of the form shown in (14) to obtain the matrix Γ. However, we need to set some parameters that will be common across all these simulations. This calibration largely follows Alessandria et al. (2023). The model frequency is quarterly. Therefore, the discount factor is set to $(1+R)^{-1} = 0.96^{1/4}$ to correspond to a 4 percent annual real interest rate R. The demand elasticity, θ, is set to be 8 in line with the tariff elasticity in Table 2. The variance of demand shocks, σ_ν, is set to 1.5. The depreciation rate of inventories, δ, is set to be 5 percent per quarter, consistent with Richardson (1995).

We simulate a wide range of ad valorem costs (ι), importers' fixed order costs (ϕ_I), and import delivery delays (μ_I). Each simulation uses a parameter vector (ϕ_I,μ_I,ι), whose elements are drawn as follows: ϕ_I ranges from 0.04 to 0.12, μ_I is varied so that import delays range between 50 and 70 days and ι varies between 1 and 1.24.[19] We draw 500 combinations of these costs. We then estimate (14) using model-simulated data on importers' total inventory holdings, the average frequency of orders, and total purchases in each steady state.

[18] Consistent with this interpretation, the last column of Online Appendix Table B.2 uses finished-goods inventories and yields the same coefficient signs, although the estimates are less precise.

[19] The range for ϕ_I is based on estimates of order costs in Alessandria et al. (2010b), the range for μ_I contains the lead times in international shipping in Alessandria et al. (2023), and the values for ι are in line with ad-valorem tariffs in emerging markets (World Trade Organization, 2017).

The results are presented in Table 3. As elaborated in the model section, these cost parameters have different impacts on the moments, each impacting one of the moments primarily. This helps us identify different cost parameters. For example, the aggregate inventory-to-sales ratios, in the first column, are mostly affected by the delivery delay. Alternatively, the ordering frequency is most sensitive to the fixed order cost, and overall imports are affected most by the multiplicative trade cost. It is important to note that while the trade literature mainly focuses on how multiplicative trade costs affect imports, in this paper we bring in additional costs firms face such as fixed order costs and delivery delays that show up in the number of times firms order and how much inventory they hold. The log-linear approximation is nearly exact over the simulated parameter grid: the R^2 values in Table 3 are 0.99 or higher.

Table 3: Model-Implied Elasticities of Moments with Respect to Trade Frictions

Dep var:	ln(inventory-sales) (1)	ln(order freq) (2)	ln(imports/domestic) (3)
ln(foreign fixed cost/revenue)	0.16	-0.51	-0.22
ln(delivery delay)	0.79	0.33	-0.43
ln(ad valorem cost)	0	0	-7.95
Observations	500	500	500
R-squared	1.00	0.99	1.00

Notes: This table shows the model-implied relationship between the cost parameters and moments as in (14) using our simulation data from the model exercise described in Section 5.1.

5.2. Decomposing the Effects of NTMs on Costs

We now translate the reduced-form effects of NTMs into economically meaningful cost components. Rather than interpreting NTMs solely through their impact on import values, this decomposition allows us to quantify how different measures distort firms' adjustment margins—specifically, their ability to place orders, manage inventories, and respond to changing economic conditions. This distinction is crucial because different types of costs have fundamentally different implications for trade dynamics and the propagation of shocks.

The results in Table 4 quantify how each NTM maps into economically meaningful cost components using the methodology outlined in Section 3.2.

Table 4: Estimated Effects of Non-Tariff Measures on Trade Costs

	NTM			
Cost	Product Standards (B7)	Import Authorization Req. (B14)	Pre-Shipment Insp. (C1)	Port-of-Entry Req. (C3)
Fixed order cost	0.61	0.81	1.18	0
Delivery delays	0.15	0.22	-0.24	0
ad valorem cost	-0.03	-0.03	0.02	0.06
Standard AVE	0	0	4.6%	5.9%

Notes: This table reports the main results of the effects of NTMs on firms' fixed order costs, delivery delays, and ad valorem trade costs. These estimates are obtained using the estimation methodology outlined in Section 3.2. The table entries correspond to the elements of matrix β in (11) and (12). The coefficients denote the log point effect of the imposition of a particular NTM on the specific cost element. For example, the presence of B7 increases fixed order costs by 0.61 log points. The reduced-form coefficients in Ξ that are not statistically significant at the 10 percent level are set to zero.

We find significant impacts of the NTMs on different dimensions of firms' costs. The results indicate that pre-shipment inspections have the largest positive impact on the fixed ordering costs firms face, more than tripling it. This is identified by the large negative impact of pre-shipment inspection (NTM C1) on the firms' number of transactions in column 2 of Table 2, the most substantial impact among the NTMs we consider. Since the pre-shipment requirement must be fulfilled for each shipment, it is reasonable to conclude that a multiplicative cost cannot capture its impact. Pre-shipment inspection (C1) requires shipments to be inspected at the port of departure from the exporting country before leaving for Indonesia. Since only two SOEs in Indonesia have the authority to carry out these inspections, this measure increases the compliance cost per shipment, thereby increasing ordering costs and inducing firms to order less frequently. This discourages frequent ordering and weakens firms' ability to adjust along the extensive margin. Import authorization requirements (B14) have the second largest effect on fixed order costs, more than doubling them, followed by product standards (B7), which increase fixed costs by approximately 84%.

NTMs also influence delivery delays faced by firms. We find that import authorization

requirements have the largest increasing on delivery delays (25%), with product standards also contributing to slightly smaller delays for firms in getting their inputs. This is reflected in the positive effect of B7 and B14 on inventory holdings, indicating that firms respond to longer delivery times by increasing buffer stocks to smooth production and sales. During a 2021 private sector roundtable hosted by the World Bank, company interviews revealed that one of the greatest challenges for Indonesian importers was the prolonged duration of the import authorization process. Shipment processes are put on hold by the exporter during the completion of the customs clearance process (submission of importation report to Ministry of Trade and submission of import authorization). Oftentimes, companies do not hear back about import authorization, or their requests get lost. Import authorization, therefore, tends to increase both the fixed ordering costs and delivery delays. Product standards similarly contribute to delivery delays as certification requires an Indonesian certifying agency to visit the factory premises. The monetary cost is compounded by the lengthy duration of the process. In addition, a lack of harmonization with international standards (e.g., medical equipment, car spare parts) creates even more delay in importing these products, as producers need to comply with Indonesia-specific standards.

Interestingly, our findings suggest that pre-shipment inspections reduce delivery times—but only after firms incur the large fixed costs associated with this NTM. This suggests that NTMs often alter the composition of trade costs rather than merely increasing their overall level. Importantly, this does not mean that NTMs reduce overall costs. Instead, it indicates that once firms commit to getting their shipments inspected at the port of departure and absorb the initial fixed costs, the subsequent shipping process becomes faster, possibly due to more streamlined procedures at destination ports. In our estimation, this is identified by the combination of this NTM reducing ordering frequency while having no significant effect on inventories. Table 3 shows that an increase in fixed ordering costs leads to a substantial decline in order frequency, but also results in higher inventory holdings. The absence of a corresponding rise in inventories in the data suggests that the NTM operates not only

through higher fixed ordering costs but also through faster shipping times.

The standard approach overlooks these NTM effects, capturing only ad valorem costs and not their impact on fixed costs or delivery delays reflected in additional data moments. We also estimate the impact of NTMs on ad valorem trade costs using our model. We find that the requirement for products to enter through specific ports and pre-shipment inspections increases multiplicative trade costs by 6% and 2%, respectively (Table 4). This is identified by the negative effect of these NTMs (codes C3 and C1, respectively) on trade flows in Table 2. Since a random sample of goods from a shipment is selected for pre-shipment inspection, a portion of the inspection costs is proportional to the shipment size, meaning larger shipments can lead to higher inspection costs. By contrast, product standards lead to a small reduction in ad valorem trade costs, which is consistent with a quality-signaling channel (Zavala et al., 2023).

These findings underscore the multidimensional effects of NTMs on costs faced by firms. We are able to capture these using our approach that allows for a broader effect of NTMs beyond just the ad valorem trade cost equivalence.[20] These estimates also clarify why the decomposition matters for policy design. A reform that lowers per-shipment compliance costs affects firms differently from a reform that shortens approval delays, even if both reforms have similar effects on average import values. Lower fixed ordering costs make firms more willing to adjust orders when conditions change, while shorter delivery delays reduce the need for precautionary inventory buffers. The cost decomposition therefore turns product-level regulatory measures into economically interpretable adjustment margins.

6. Impact and Propagation of Shocks with NTMs

We now study how NTMs alter the dynamic response of the economy to trade shocks. In environments with inventories and lumpy ordering, the effects of shocks depend critically

[20]The robustness of these cost decompositions to alternative values of the variance of idiosyncratic demand shocks, σ_ν, and the inventory-depreciation rate, δ, is examined in Online Appendix C.

on how easily firms can adjust along different margins. By changing fixed ordering costs and delivery delays, NTMs reshape both the immediate response to shocks and the speed of recovery. This exercise connects micro-level regulatory design to macro-relevant adjustment. Licensing, inspection, certification, and port-entry rules are imposed at the product or shipment level, but they affect outcomes beyond the level of trade by changing firms' ordering frequency, inventory buffers, and speed of recovery after shocks. The shock exercises therefore show how administrative trade frictions can influence supply-chain resilience, price persistence, and the propagation of temporary policy changes.

We consider two types of temporary shocks: (i) a disruption to supply chains, modeled as an increase in delivery times, and (ii) a temporary increase in tariffs, modeled using the same stochastic process. This unified framework allows us to compare how different shocks interact with the cost structure induced by NTMs and to isolate the mechanisms through which NTMs amplify or dampen trade responses.

We begin by setting the fixed ordering costs, delivery delays, and ad valorem costs in the baseline economy without NTMs using standard values from the literature. Fixed ordering costs are set to 12 percent of quarterly firm revenue and delivery delays to 45 days, following Alessandria et al. (2023). We set the ad valorem cost to 5 percent. We then incorporate the estimated effects of NTMs on these cost components from Section 5.2, summarized in Table 4, to construct counterfactual economies associated with each NTM. The resulting trade costs are reported in Table 5. The most notable changes are the increase in delivery times under product standards ($B7$) and import authorization requirements ($B14$), and the large rise in fixed ordering costs under pre-shipment inspections ($C1$), while port-of-entry restrictions ($C3$) primarily affect the multiplicative cost.

We next examine how these differences in cost structure translate into differences in the impact and propagation of shocks.

Table 5: Cost Parameters Used in the Counterfactual Exercises

	Fixed order cost	Delivery Delay	Ad valorem cost
Baseline	12	45	1.05
Product Standards (B7)	22	53	1.02
Import Authorization Req. (B14)	27	56	1.01
Pre-Shipment Insp. (C1)	39	35	1.08
Port-of-Entry Req. (C3)	12	45	1.11

Notes: This table shows the cost parameters in the baseline and in cases with individual NTMs, simulated in Figures 2 and 3. Fixed order costs are expressed as a percentage of average quarterly revenue in the baseline version. Delivery delays are expressed in days.

6.1. Supply Disruptions in the Presence of NTMs

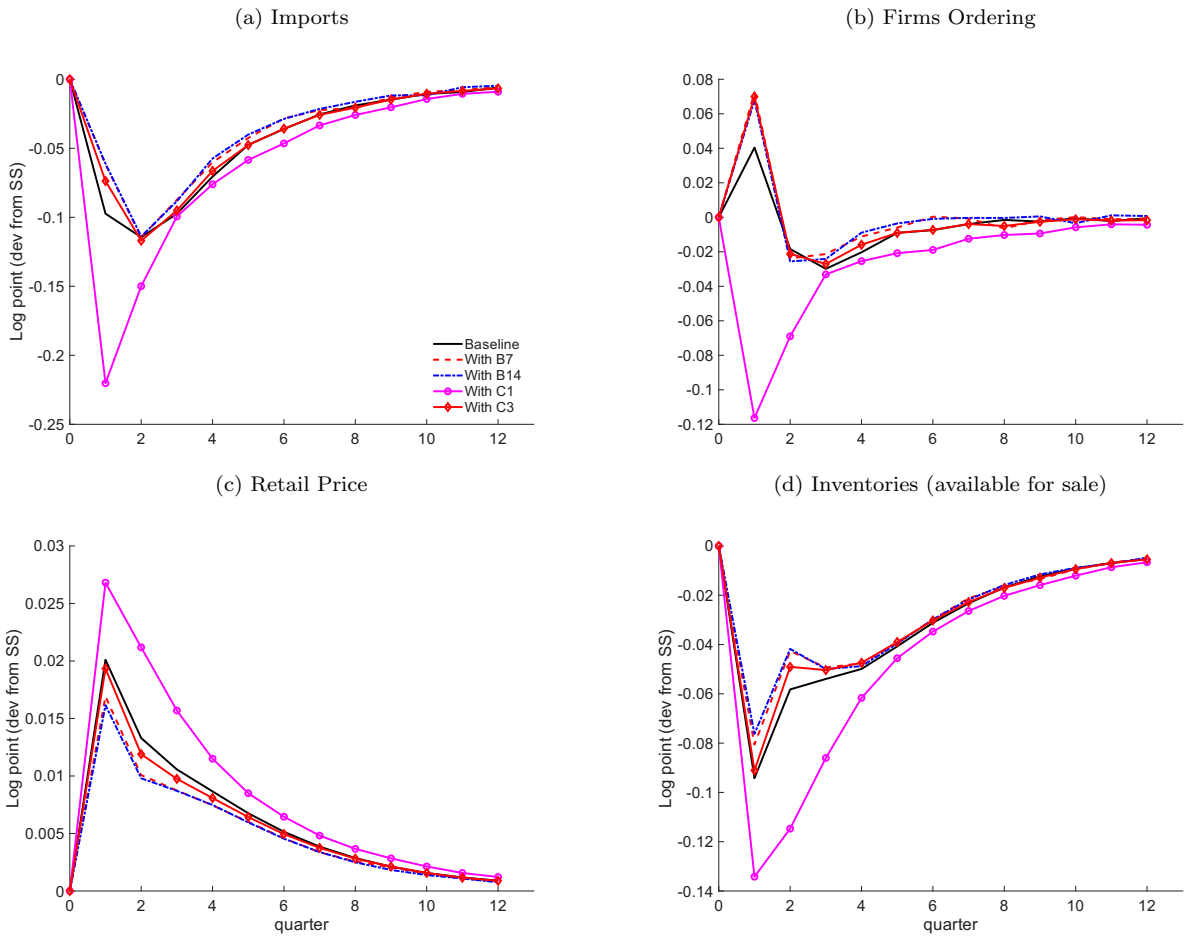
We study how NTMs shape the impact and propagation of supply disruptions. We model a disruption as a temporary increase in delivery times of 10 days, following an autoregressive process with persistence 0.75, corresponding to a shock lasting approximately four quarters.[21]

Figure 2 reports the dynamic responses of imports, the fraction of firms placing orders, retail prices, and inventories available for sale. In the baseline without NTMs, an increase in delivery times reduces the arrival of goods on impact, leading to a decline in imports. Firms respond by increasing ordering activity in an attempt to rebuild inventories, but inventories available for sale nevertheless fall, tightening inventory constraints and raising retail prices. As delivery conditions normalize, inventories and ordering activity gradually recover.

The presence of NTMs alters these dynamics in ways that reflect their underlying cost structure. The most pronounced effects arise under pre-shipment inspections ($C1$), which substantially raise fixed ordering costs. In this case, inventories available for sale experience the largest decline. The mechanism is driven by the interaction between the delay shock and the high fixed cost of ordering: when delivery times are temporarily elevated, firms optimally delay ordering to avoid paying high fixed costs, effectively substituting intertemporally. As a result, the increase in ordering activity observed in the baseline doesn't happen, leading to a sharper reduction in inventories available for sale. This amplifies the decline in imports

[21] The magnitude of the shock is chosen to reflect disruptions observed during the pandemic, when delivery delays at major ports increased by 10–20 days (Komaromi et al., 2022).

Figure 2: **Temporary Increase in Delivery Times by 10 Days**



Notes: B7 denotes product standards; B14, import authorization requirements; C1, pre-shipment inspections conducted at the port of departure; and C3, port-of-entry restrictions requiring imports to enter through designated ports.

and results in a larger increase in retail prices. The high fixed cost also slows the recovery, as firms adjust more gradually when replenishing inventories. This shows how a micro-level per-shipment procedure can amplify a supply disruption because it discourages firms from rebuilding inventory precisely when delivery conditions deteriorate.

In contrast, product standards ($B7$) and import authorization requirements ($B14$) primarily operate by increasing delivery delays. These longer delays induce firms to hold larger inventories in steady state, which partially cushions the initial impact of the disruption. As a result, inventories available for sale decline by less on impact compared to the $C1$ case. However, because delivery frictions remain elevated, the recovery is slower: inventories take longer to rebuild and the effects of the shock persist over a longer horizon.

Port-of-entry restrictions ($C3$), which mainly affect ad valorem costs, have only minor effects on these dynamics. The responses of inventories, imports, and prices closely track those in the baseline, indicating that ad valorem costs play a limited role in shaping adjustment to delivery shocks.

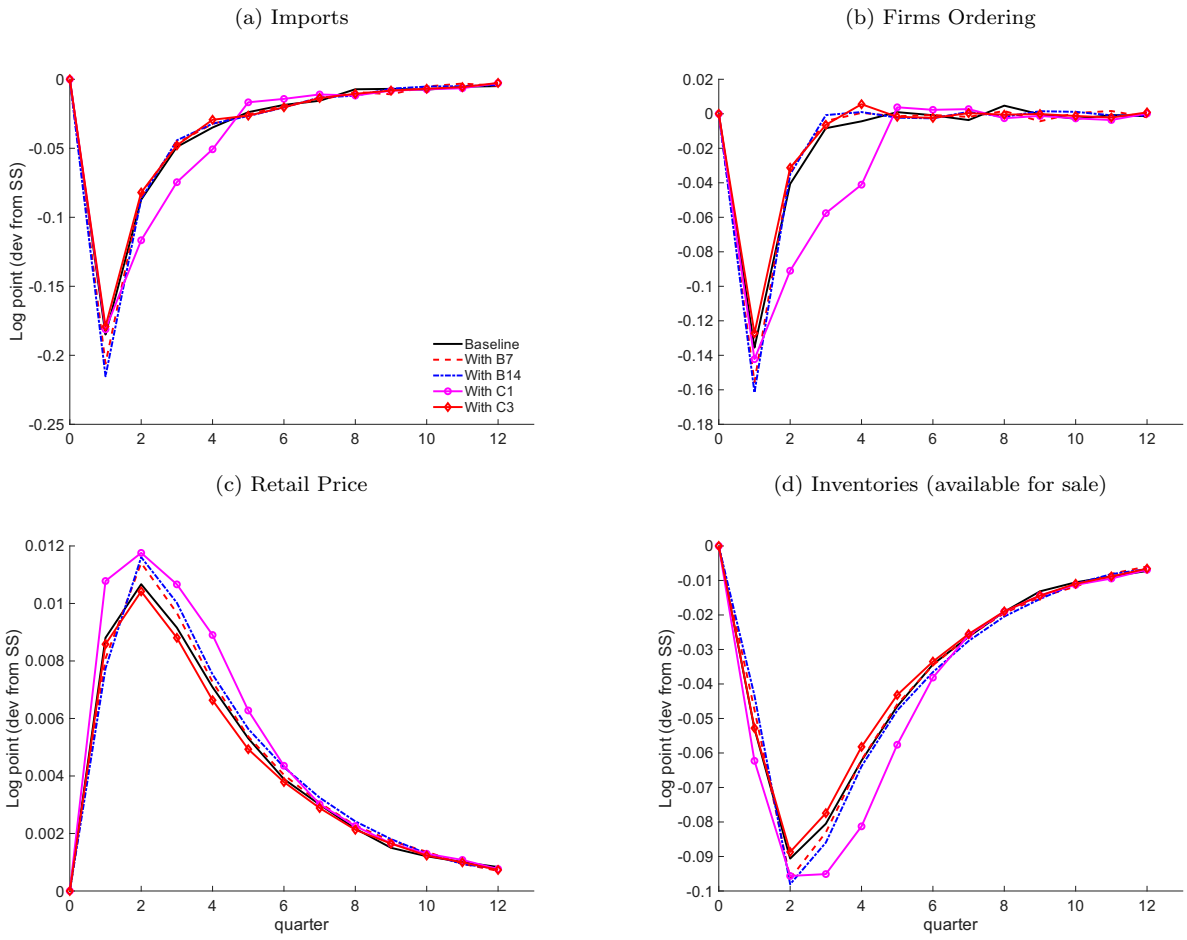
Overall, these results highlight that fixed ordering costs and delivery delays affect supply disruptions through distinct channels. High fixed costs amplify disruptions by inducing firms to delay ordering in response to temporarily unfavorable conditions, leading to sharper declines in inventories available for sale.

6.2. Tariff Increase in the Presence of NTMs

We next examine how NTMs shape the dynamics of a temporary tariff shock. To facilitate comparison with supply disruptions, we model the tariff as a transitory increase that follows the same autoregressive process as the delivery-time shock.

Figure 3 reports the dynamic responses of imports, the fraction of firms placing orders, retail prices, and inventories available for sale. In the baseline without NTMs, the temporary tariff increase leads to a decline in imports on impact, as firms reduce ordering and instead draw down inventories. As a result, inventories available for sale fall and retail prices increase, with gradual recovery as the tariff decays.

Figure 3: **Temporary Tariff Increase by 1 Percentage Point**



Notes: B7 denotes product standards; B14, import authorization requirements; C1, pre-shipment inspections conducted at the port of departure; and C3, port-of-entry restrictions requiring imports to enter through designated ports.

NTMs significantly modify these dynamics through their effect on ordering costs and delivery frictions. Under pre-shipment inspections ($C1$), the high fixed ordering cost slows the rebuilding of inventories. As shown in panel (d) of Figure 3, inventories available for sale remain depressed for longer, reflecting the fact that firms face higher costs when placing new orders. This leads to a more persistent decline in imports and a more prolonged increase in retail prices. The key mechanism is that high fixed costs make it costly to adjust along the extensive margin, delaying the recovery of inventory positions.

Port-of-entry restrictions ($C3$), which mainly increase ad valorem costs, have relatively modest effects on inventory dynamics. Since ad valorem costs affect all shipments proportionally and do not distort the timing of orders, the responses remain close to the baseline. The effects of product standards ($B7$) and import authorization requirements ($B14$), both of which affect fixed order costs but less than pre-shipment inspections, lie in between.

Taken together, these results show that fixed ordering costs and delivery delays have distinct implications for the dynamic response to tariff shocks. High fixed costs prolong adjustment by slowing inventory rebuilding, while delivery delays affect the short-run response by altering firms' reliance on inventory buffers. As a result, NTMs not only affect the level of trade costs but also reshape the timing and persistence of trade responses to temporary policy shocks. Thus, NTMs can make temporary policy shocks behave as if they were more persistent. Even after the tariff begins to unwind, firms subject to high ordering costs rebuild inventories slowly, prolonging the effects on imports and retail prices.

7. Heterogeneity by End Use

NTMs are often implemented through administrative and regulatory procedures whose effective incidence can vary with the nature of the product. Unlike tariffs—which are proportional and therefore apply uniformly across goods—NTMs may impose different frictions depending on whether goods are used for production, consumption, or investment. This raises the question of whether the average effects identified in the baseline reflect uniform

distortions across goods, or instead mask systematic heterogeneity in regulatory implementation across end-use categories.

In this section, we examine how the effects of NTMs vary across broad end-use categories. We first document heterogeneity in the reduced-form responses of imports, transaction frequency, and inventory holdings. We then map these responses into model-implied cost components and compare them to the baseline decomposition that pools across all products. This exercise provides a sharper interpretation of how different NTMs operate in practice and highlights the extent to which the aggregate results reflect a combination of distinct underlying mechanisms.

7.1. Empirical Evidence by End-Use Category

To examine whether the effects of NTMs vary across the end-use of imported goods, we extend the baseline specifications to allow the four NTM coefficients to differ by BEC end-use category—Capital, Consumption, and Intermediate goods.[22]

For import values and transaction frequency, we replace the NTM exposure measures in (17) with end-use interaction terms, retaining the same set of fixed effects and control variables as in our main Table 2. For the inventory regressions, we assign each input sector to a single BEC category. We then construct three separate NTM exposure measures for each destination sector corresponding to capital goods, consumption goods, and intermediate inputs. Each measure captures the share of inputs used by sector s that belong to a given end-use category and are subject to a particular NTM.

Formally, for each BEC category $b \in \{\text{capital, consumption, intermediate}\}$, destination sector s, and year t, we define

$$NTM^{b}_{s,t} = \sum_{r} \omega_{sr} \cdot NTM_{r,t} \cdot \mathbf{1}_{\{r \in b\}}, \tag{21}$$

[22]Some products are marked as "unspecified" in the HS-to-BEC concordance. We drop them for this section.

where ω_{sr} denotes the input share of sector r in sector s, and the indicator function restricts the summation to inputs belonging to category b.

This construction yields three exposure measures that decompose a sector's overall NTM exposure according to the composition of its inputs. Each measure captures the share of inputs in a given category that are subject to the NTM, without re-scaling the underlying input shares. As a result, the magnitude of $NTM_{s,t}^{b}$ is directly tied to the importance of that input category in production. This allows us to test whether the inventory response to a given NTM differs depending on whether the affected inputs are primarily capital goods, intermediates, or consumption goods. Table 6 contains the results.

The results reveal meaningful heterogeneity across end-use categories. Comparing Tables 2 and 6 shows that the effects of NTMs differ both across margins and across product types.

For product standards ($B7$), the decline in ordering frequency is primarily driven by intermediate goods, while the increase in inventory holdings is concentrated in consumption goods. This pattern suggests that standards alter ordering behavior for production inputs, while inducing higher inventories for final consumption goods.

Import authorization requirements ($B14$) generate large and precisely estimated reductions in transaction frequency, with the strongest effects for capital goods—approximately 2.5 times larger than for consumption goods. At the same time, $B14$ increases inventory holdings for intermediate goods. The negative effect on import values is concentrated in consumption goods, with little impact on other categories. Pre-shipment inspections ($C1$) reduce ordering frequency for both consumption and intermediate goods, with a larger effect for consumption goods, while their negative effect on import values is significant only for intermediate goods. Finally, port-of-entry restrictions ($C3$) are broadly insignificant across all end-use categories. While the estimated effects on imports and transactions are consistently negative, they are imprecisely measured.

Overall, these results show that the same NTM can affect different margins of firm

Table 6: Reduced-Form Effects of NTMs by End-Use Category

		ln(imports)	ln(#transactions)	ln(Inv/Purch)
		(1)	(2)	(3)
d_{B7} (Product Standards)				
	Capital	-0.08	0.45	-0.88
		(0.56)	(0.37)	(2.80)
	Consumption	0.15	-0.45	0.25*
		(0.59)	(0.31)	(0.13)
	Intermediate	-0.14	-0.34*	0.22
		(0.32)	(0.18)	(0.18)
d_{B14} (Import Authorization Req.)				
	Capital	-0.30	-1.16***	6.92
		(0.41)	(0.33)	(8.48)
	Consumption	-0.56*	-0.46**	0.24
		(0.31)	(0.19)	(0.68)
	Intermediate	0.05	-0.17	0.32*
		(0.21)	(0.11)	(0.19)
d_{C1} (Pre-Shipment Insp.)				
	Capital	0.12	-0.36	-6.93
		(0.37)	(0.32)	(8.57)
	Consumption	-0.62	-0.94***	0.60
		(0.44)	(0.29)	(0.68)
	Intermediate	-0.48*	-0.73***	0.01
		(0.27)	(0.15)	(0.14)
d_{C3} (Port-of-Entry Req.)				
	Capital	-0.40	-0.23	8.12
		(0.60)	(0.43)	(8.31)
	Consumption	-0.32	-0.23	-0.13
		(0.28)	(0.17)	(0.12)
	Intermediate	-0.55	-0.11	-0.06
		(0.37)	(0.21)	(0.06)
Tariff		-6.75***	-2.56***	—
		(1.49)	(0.95)	
NTM category counts		✓	✓	✓
HS4 FE		✓	✓	
HS2-Year FE		✓	✓	
Year FE				✓
Firm FE				✓
N		17,347	17,347	85,945
R2		0.55	0.62	0.79

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table reports estimates of the heterogeneous effects of NTMs by BEC end-use categories on annual import values (col. 1), the number of import transactions (col. 2), and inventory holdings relative to purchases (col. 3). All fixed effects and controls are the same as in Table 2.

behavior depending on the end-use of the good, highlighting that average estimates mask important underlying heterogeneity.

7.2. Cost Decomposition by End Use

We next map the heterogeneous reduced-form responses into model-implied cost components and relate them to the baseline decomposition that pools across all products. Table 7 reports the decomposition of NTMs into fixed ordering costs, delivery delays, and ad valorem costs across end-use categories.

Table 7: Estimated Effects of Non-Tariff Measures by Broad Category

Cost	Product Standards (B7)	Import Authorization Req. (B14)	Pre-Shipment Insp. (C1)	Port-of-Entry Req. (C3)
Panel A. Capital goods				
Fixed order cost	0.00	2.01	0.00	0.00
Delivery delays	0.00	-0.41	0.00	0.00
Iceberg cost	0.00	-0.03	0.00	0.00
Panel B. Consumption goods				
Fixed order cost	0.18	0.80	1.63	0.00
Delivery delays	0.28	-0.16	-0.33	0.00
Iceberg cost	-0.02	0.06	-0.03	0.00
Panel C. Intermediate goods				
Fixed order cost	0.59	0.23	1.27	0.00
Delivery delays	-0.12	0.36	-0.26	0.00
Iceberg cost	-0.01	-0.03	0.04	0.00

Notes: This table reports the estimated effects of non-tariff measures on firms' fixed order costs, delivery delays, and ad valorem trade costs separately for capital goods, consumption goods, and intermediate goods. Each panel is constructed using the baseline model matrix together with the corresponding empirical Γ_β matrix for that broad category. The table entries correspond to the elements of the implied cost matrix β. The reduced-form coefficients in Ξ that are not statistically significant at the 10 percent level are set to zero.

The results reveal systematic differences in how NTMs translate into underlying frictions. Product standards (B7) increase fixed ordering costs for consumption and intermediate goods, with negligible effects for capital goods. However, the associated delivery delays are concentrated in consumption goods, while being small or negative for intermediates. The aggregate delay effect of $B7$ in the baseline reflects a combination of heterogeneous responses across product types.

Import authorization requirements ($B14$) similarly raise fixed ordering costs across all categories, with the largest effect for capital goods. In contrast, delivery delays rise only for intermediate goods and are negative for capital and consumption goods. Thus, the aggregate delay effect of $B14$ in the baseline reflects the composition of these heterogeneous responses, combining timing frictions for production inputs with fixed costs for capital goods.

Pre-shipment inspections ($C1$) continue to operate primarily through fixed ordering costs, with large effects for both consumption and intermediate goods and negligible effects for capital goods. The associated delivery delays are negative for consumption and intermediate goods and zero for capital goods, indicating that the baseline delay effect for $C1$ reflects an average across heterogeneous responses.

Finally, port-of-entry restrictions ($C3$) have negligible effects across all cost components when estimated by end-use category. The positive ad valorem cost associated with $C3$ in the baseline decomposition does not persist in the disaggregated results, consistent with the weak and imprecise reduced-form estimates across all categories in Table 6.

Overall, these results show that the economic impact of NTMs depends not only on their type but also on the nature of the goods they affect. The same policy can distort different margins of firm behavior across sectors depending on how it is implemented, leading to heterogeneous effects on trade flows, inventories, and adjustment dynamics.

8. Conclusion

This paper brings a fresh perspective to the literature on non-tariff measures and shows that the economic effects of NTMs extend well beyond standard ad-valorem trade costs by fundamentally altering firms' adjustment margins. Using firm-level data on imports, transactions, and inventories, we develop a framework to decompose NTMs into fixed ordering costs, delivery delays, and ad valorem costs. This decomposition reveals that many NTMs operate primarily by affecting how firms adjust over time—through ordering frequency, inventory management, and the timing of trade—rather than simply raising the cost of imports.

These distinctions have important implications for how trade policy affects the economy. We show that NTMs reshape the dynamic response to both supply disruptions and tariff shocks. Fixed ordering costs amplify shocks by limiting firms' ability to adjust along the extensive margin, leading to sharper contractions and more persistent recoveries. Delivery delays, in contrast, alter firms' inventory behavior, increasing reliance on buffer stocks and changing the timing of adjustment. As a result, policies with similar ad-valorem equivalents can have very different effects on trade flows, prices, and the persistence of shocks.

Our results also highlight that the economic impact of NTMs depends on the nature of the goods they affect. The same policy can operate through different margins across capital, consumption, and intermediate goods, implying that average measures may mask important heterogeneity in how different measures are implemented. This underscores the importance of moving beyond common trade costs to understand the sectoral and compositional effects of policy interventions.

More broadly, the framework developed in this paper provides a new approach for evaluating trade policy in environments with inventories and lumpy adjustment. By linking observed firm behavior to underlying cost structures, it allows researchers to study how different policies affect not only the level of trade but also its dynamics and resilience. This is particularly relevant in the current global environment, where supply chain disruptions and the increasing use of regulatory trade measures have made the timing and reliability of trade flows as important as their cost. The estimated wedges measure the private trade and adjustment costs of these measures rather than their full social value. Some NTMs pursue legitimate safety, quality, or information objectives, so the relevant policy comparison is among regulatory designs that deliver those objectives with different per-shipment costs and delays. The model's firm-value and retail-price responses measure private incidence, while a complete welfare calculation must additionally value regulatory benefits and general-equilibrium effects.

Several directions for future research follow from our analysis. First, incorporating these

multi-dimensional trade costs into general equilibrium models would allow for a more complete assessment of welfare and policy trade-offs, particularly in the presence of distortionary taxation or strategic trade interactions. Second, extending the framework to study firms' sourcing decisions and supplier diversification could shed light on how NTMs affect supply chain resilience. Finally, the interaction between NTMs and expectations—such as anticipated policy changes or uncertainty about trade restrictions—remains an important area for understanding the dynamic effects of trade policy.

Taken together, our findings suggest that evaluating trade policy requires going beyond static measures of trade costs to account for how policies affect firms' dynamic responses. NTMs, by shaping adjustment margins and the timing of trade, play a central role in determining not only how much trade occurs, but how the economy responds to shocks.

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Declaration of AI-assisted technology

During preparation of this manuscript, the authors used OpenAI to assist with revising grammar, identifying relevant literature, reviewing author-written code for potential errors, and checking consistency across the manuscript, code, and reported results. The authors wrote the original research code, reviewed and edited the AI-assisted material, and take full responsibility for the content of the published article.

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