

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

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Abstract

Rising protectionism has shifted trade policy toward non-tariff measures (NTMs), yet their economic effects are not well captured by standard ad-valorem equivalents. This paper shows that NTMs affect trade not only by raising costs, but by altering firms' adjustment margins and trade dynamics. We assemble a novel, highly disaggregated dataset of NTMs and combine it with transaction-level import and inventory data from Indonesia. Embedding these data in a dynamic trade model, we map observed firm behavior—imports, ordering frequency, and inventories—into underlying cost components, allowing us to decompose NTMs into fixed ordering costs, delivery delays, and iceberg costs. We find that NTMs impose substantial non-ad-valorem frictions. Pre-shipment inspections primarily increase fixed ordering costs, while product standards and import authorization requirements raise both fixed costs and delivery delays. NTMs significantly reshape the response to trade shocks. In the presence of NTMs, supply disruptions lead to larger inventory drawdowns and more persistent price increases, while temporary tariff shocks become more persistent due to slower inventory rebuilding. We also document substantial heterogeneity across end-use categories, with the same NTM operating through different adjustment margins across capital, consumption, and intermediate goods. Overall, our results show that NTMs play a central role in shaping not only the level of trade, but also how trade adjusts and evolves in response to shocks.

JEL Classifications: F13, F15

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1 Introduction

Rising geopolitical tensions have led to more protectionism and increasing use of non-tariff measures, often on political grounds (Aiyar et al., 2023; Campos et al., 2023). Recent examples include trade tensions between US 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 tariff 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. However, despite the widespread use of such non-tariff measures and the increasing interest among policy makers regarding their costs, little is known about the cost incidence these measures impose on firms which matters for firms’ adjustment behavior and the resulting economic impact of trade shocks.

The standard approach to representing trade costs is through an “iceberg” or multiplicative cost. While this approach of modeling is motivated by a particular type of trade policy measure, the ad-valorem tariff, a wide range of other types of trade barriers — the non-tariff measures (NTM) — involve bureaucratic procedures resulting in transaction costs that need not be proportional to the value of shipments. The general approach taken in the literature is to convert the NTMs into ad-valorem equivalents that show up as reduced import values, thus making them comparable to tariffs (Kee and Nicita, 2022). However, not all trade costs are reflected in import values. For example, pre-shipment inspections, which require shipments to be inspected at the port of departure, may increase fixed order costs of shipments. Such delays may not be clearly reflected in import values, as they primarily affect firms’ inventory holdings or shipping schedules as firms opt for larger, less frequent shipments. As a result, standard approaches miss how NTMs reshape firms’ adjustment margins—how often they order, how much they store, and how they respond to shocks.

This paper presents a comprehensive analysis of the nature and types of costs that disaggregated non-tariff measures impose, by considering not only their ad-valorem component but also their effects on fixed costs and delivery delays. This allows us to quantify how this specific form of trade policy influences the propagation of supply disruptions and tariff shocks over time, as reflected in firm imports and retail prices of imported goods. These dynamics imply that two policies with similar ad-valorem equivalents can have very different effects on trade, prices, and volatility. We do this by considering the effects of specific NTMs on firms’ ordering frequency and inventory holdings in addition to their effects on firms’ imports. This brings to light new moments that help us decompose the effects of NTMs into

standard and non-standard cost elements. First, we build a model where firms face fixed costs and delivery delays in addition to the standard iceberg costs which leads them to order inputs infrequently and hold inventories. This model provides a mapping from observed firm behavior to underlying cost components, allowing us to recover fixed costs and delivery delays from data. Second, we use detailed firm-level monthly customs trade data and plant-level data from the Indonesian survey of manufacturing plants, matched with product-level information on NTMs to help uncover the impact of different types of NTMs on imports, the level of inventories, and ordering frequency. Third, we employ a novel identification strategy to decompose the observed effect of NTMs on firms' characteristics in terms of the underlying unobserved costs by combining the insights from data with the model-implied relationship between firm behavior and cost parameters. Our primary finding reveals that NTMs significantly increase both fixed costs and delivery delays for firms, with significant heterogeneity across types of NTMs. For example, while port-of-entry restrictions primarily affect import values, reflected in iceberg costs, pre-shipment inspections primarily affect the frequency of transactions and inventory holdings, reflected in fixed costs. Therefore, estimating the ad-valorem equivalents based solely on the impact of aggregated NTMs on imports overlooks key aspects of the overall effects of NTMs, both across diverse types of NTMs and across different firm behaviors.

While data on import tariffs are relatively easily available, a key innovation of this paper is the extensive coverage of NTMs, which represent increasingly important but still under-researched trade policy instruments (Nicita, 2012). Specifically, we address the data limitation by assembling a novel hand-collected database of NTMs from different regulatory agencies in Indonesia for 2014-2018. We then link these NTMs (as well as tariffs) to firm-level customs data at the 10-digit HS level, the most detailed product classification available. This allows us to depart from previous studies on NTMs which either rely on aggregate measures (Looi Kee et al., 2009) or focus on broad categories of NTMs such as sanitary and phytosanitary measures (SPS) and technical trade barriers (TBT) (Fontagné et al., 2015). Importantly, unlike other studies, this allows us to analyze the effects of NTMs beyond import values, on the frequency of ordering and the levels of inventory, moments that are typically affected by fixed ordering costs and delivery delays. To unpack the effects of NTMs on the different dimensions of cost, it is important to look at more disaggregated NTMs for two reasons: First, there is a wide variety in the type and hence the nature of costs these NTMs entail, even within the same broad classification. For example, even though both NTMs C1 and C3 fall under the broad category "INSP" (inspections), while C1 or Pre-Shipment Inspections (PSI) requires shipments to be inspected at the port of departure from the exporting country, C3 relates to the obligation that certain imported goods must

enter through designated ports in the importing country. Second, not all NTMs impose costs that will show up as reduced imports, which is what usually allows the computation of the ad-valorem equivalence of NTMs. Some NTMs, such as SPS, can increase the quality of goods, thereby increasing demand for these products and hence imports ([Zavala et al., 2023](#)).

In this paper, we focus on four NTMs. We identify these measures on the basis of three conditions: (i) increasing import costs; (ii) not being necessary to achieve a well-defined public policy objective; and (iii) being widely applied. On the basis of these criteria, we are able to identify four distinct NTM measures. These include — in decreasing order of import coverage ratio: import approval requirements (IAR, coded B14 as per UNCTAD’s MAST terminology), pre-shipment inspections (PSI, coded C1), quality and safety requirements (QSR, coded B7) and port of entry restrictions (PER, coded C3). In our empirical analysis, we study the effects of these four NTMs on import values, the frequency of transactions, and firm-level inventories, controlling for all other NTMs (such as SPS measures), unobserved demand shocks (product-time fixed effects), and time-varying shocks (time fixed effects).

The main aim of our exercise is to translate the observed effects of NTMs on firm behavior into specific types of trade costs faced by firms. To achieve this, we utilize a model that maps the impact of NTMs on data moments — such as firms’ ordering frequency and inventory holdings — into unobserved cost elements like fixed order costs and delivery delays. Specifically, we employ a dynamic discrete choice trade model, based on [Alessandria et al. \(2010\)](#), of heterogeneous firms encountering international transaction frictions. These frictions prompt firms to order inputs infrequently and maintain inventories. In contrast to the standard trade frameworks, the presence of fixed ordering costs and delivery lags in this model and its relationship between observed firm behavior in terms of ordering frequency and inventory holdings make it particularly well-suited to estimate the broader effects of NTMs. We introduce a straightforward yet powerful identification strategy that decomposes the effects of NTMs into non-ad-valorem costs. We begin by estimating the direct reduced-form effect of NTMs on firm characteristics — inventories, ordering frequency, and import values. We then use a model-implied relationship between unobserved costs and these observable firm characteristics to decompose the effect of NTMs into standard ad valorem as well as non-standard fixed costs and delivery delays.

Pre-shipment inspections have the largest positive impact on fixed ordering costs firms face, by more than tripling it. Since the pre-shipment requirement must be fulfilled for each shipment, it is reasonable to conclude that a multiplicative iceberg cost cannot capture its impact. Import authorization (B14) has the second largest impact on fixed order costs, more than doubling them, followed by product standards (B7), which increase fixed order costs

by 84%. NTMs also influence delivery delays faced by firms with import authorization requirements having the largest effect on delivery delays (25%). 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 approval process. We also estimate the impact of NTMs on standard trade cost as well, finding that port of entry requirements lead to a 6 percentage point increase in iceberg trade cost for affected products.

We show that these effects vary systematically across end-use categories, reflecting differences in how NTMs interact with production and sourcing decisions. Import authorization requirements (B14) impose the largest burden on transaction frequency for capital goods — reducing it by more than twice the magnitude observed for consumption goods — while also inducing firms importing intermediate inputs to hold significantly larger inventories as a precaution against delivery delays. Pre-shipment inspections (C1) generate persistent negative effects on both import values and ordering frequency that are concentrated among intermediate goods, suggesting this measure is especially disruptive for firms embedded in production networks that depend on frequent, reliable input sourcing. Overall, these findings show that NTMs are not only multi-dimensional but also end-use dependent, with the same policy instrument affecting different margins of firm behavior depending on the economic role of the good.

Finally, we show that NTMs shape the dynamic impact of trade shocks, like supply disruptions and tariff changes. In response to disruptions modeled as temporary increases in delivery times, high fixed ordering costs—particularly under pre-shipment inspections—amplify the decline in inventories available for sale by inducing firms to postpone ordering when delays are elevated. This leads to larger contractions in imports, sharper increases in prices, and slower recovery dynamics. In contrast, NTMs that increase delivery delays, such as product standards and import authorization requirements, induce firms to hold higher inventory buffers, which dampens the initial price impact but prolongs the adjustment. A similar distinction arises for tariff shocks. High fixed ordering costs amplify the contraction in trade and slow the rebuilding of inventories, making the effects of temporary tariffs more prolonged. Delivery delays, by contrast, increase firms’ reliance on inventories, leading to larger short-run responses but smoother recovery. These results show that NTMs not only affect the level of trade costs but also fundamentally alter the timing and persistence of trade responses, implying that policies with similar ad-valorem equivalents can have very different economic consequences.

1.1 Related Literature

Our paper is related to two strands of literature: First, the literature that studies the importance of different types of trade costs in driving trade flows. Seminal work by [Alessandria et al. \(2010\)](#) 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. 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 have 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 ([Irrazabal 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 costs to moments 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.¹ 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.² 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. Measures such as pre-shipment inspections and import approvals can affect fixed costs of importing, thereby impacting the firm’s inventory holdings and frequency of transactions but not import values. Second, we show that different types of NTMs within the same broad

¹See [Ederington and Ruta \(2016\)](#) for a survey of the literature.

²[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](#))

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 we employ to identify various costs elements and discusses the identification strategy. Section 4 contains the empirical results. Sections 5 and 6 describe the model quantification and an application of the model to how NTMs shape the dynamic response of firms to trade shocks. Section 7 investigates whether the baseline effects of NTMs differ by end use and section 8 concludes.

2 Data

To carry out the analysis, we make use of three novel sources of data. The first is monthly data on the universe of Indonesian exporters and importers which was confidentially shared by the Indonesian Directorate General of Customs and Excise (DGCE, referred to as DG Customs in the paper) within the Ministry of Finance.³ The second is a time-varying data of NTMs at a highly disaggregated level of sectoral classification (HS-10 digit), which was assembled and maintained for Indonesia by the World Bank. This data was compiled based on extensive regulatory checks and varies monthly at 3-digit MAST classification and 10-digit HS level. The third source is plant-level data taken from the Indonesian survey of manufacturing plants with at least 20 employees.

2.1 Indonesian customs data

For the trade data, we use customs-level monthly data covering the universe of Indonesian importers from 2014 to 2018. 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 of the appealing features of these datasets is the highly disaggregated level (10-digit HS code) at which they are recorded. The data contains the monthly dollar value and quantities of imports at the firm-year-month-HS-10 product level, along with information on the country of origin for imports.

³This was the result of an ongoing collaboration with the World Bank office in Jakarta.

2.2 Indonesian 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 [Cali 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 digits 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 2 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 plant-level manufacturing dataset is the measurement of inventories at the plant-level, which is rarely available in other datasets and which helps us study the effect of non-tariff measures on delivery delays, which affect inventories. Inventories are expressed as (log) end-of-year values of raw materials and semi-finished goods. For our regressions, we normalize inventories with total raw material purchases in the year and winsorize the inventory-purchase ratio to only consider the observations within 5th and 95th percentiles. In a typical year, a median firm holds 3.6 months' worth of purchases in inventories.

2.3 Indonesian NTM and tariff data

NTM-related regulations have been spread out among a total of 13 government institutions (ministries, agencies, and some are issued as a presidential decree) during our period of analysis (2014-2018). Each institution has its own mandate. This makes monitoring NTMs difficult since no dedicated government institution can carry out NTM regulatory review and stocktaking ([Munadi, 2019](#)).

To overcome these issues, we use a novel comprehensive NTM data-base 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 data identifies the stock of NTMs applied by Indonesia as of 2015. The data 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 2015.⁴ The data 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 data 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 studying the effects of specific NTMs, as detailed below in subsection 2.3.1.

In addition, we complete the trade policy data with import tariff data collected by the UNCTAD Trade Analysis Information System (TRAINS) data-set. For Indonesia, this data includes yearly Most Favored Nations (MFN) applied import tariff at the HS 10-digit product level.⁵

2.3.1 Selecting NTMs for analysis

Table 1 contains the list of NTMs that affect at least 10% of products at the HS-8 digit level during 2008-2021. We rank the NTMs by the share of value of intermediate products that they affect, which range from 6%-38%. Out of these 10 NTMs, we separately analyze 4 NTMs that have been identified as purely protectionist in Calì et al. (2024) and Calì et al. (2022). We briefly summarize the method to identify these 4 NTMs as deployed in Calì et al. (2024) and Calì et al. (2022). We identify these measures on the basis of three conditions: (i) increasing import costs; (ii) not being necessary to achieve a well-defined public policy objective; (iii) being widely applied. On the basis of these criteria, we are able to identify four distinct NTM measures. These include Import Approval Requirements (IAR) or B14 as per UNCTAD’s MAST terminology, Pre-Shipment Inspections (PSI) or C1, Port of Entry Restrictions (PER) or C3, and Compliance with National Standards or B7. 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 Approval Requirements (B14) and Pre-Shipment Inspection (C1). Between 28-40% of firms faced Compliance with National Standards or B7 while less than 30% of firms faced Port of Entry restrictions (C3). The same ordinal pattern persists if we look at coverage

⁴ERIA has updated the data and the latest one is 2018, where some of these coding errors may have been addressed. Calì and Montfaucon (2021) details the process, dissimilarities, and coding errors corrected by the data. Additionally, Montfaucon et al. (2023) also provides more details on the construction of the data and the institutional context.

⁵The MFN typically provides an upper bound of the applied tariff as it does not include preferential tariff regimes. However, the MFN is the most appropriate tariff data in our paper which does not distinguish between import sources.

ratio, which is the share of imports subject to NTMs. 30% or more of total imports are subject to B14 and C1 while between 10-20% of all imports are subject to B7 and C3.

As NTMs are heterogeneous in their application and cost implications, it is necessary to use highly disaggregated levels of NTMs. At the same time, we control for all other NTMs in our analysis, using the broad NTM categories such as SPS and TBT.

Import Approval Requirements

The first measure is *Import Approval Requirements* (B14). This is issued by the Ministry of Trade, with supporting specific 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 approval 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 Inspection

The second measure *PSI* (C1) requires shipments to be inspected at the port of departure from the exporting country before leaving for Indonesia. The objective of PSI 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 PSI for the Indonesian government. Besides the fees for this service, the cumbersome process to comply with this measure can increase the cost of importing by raising the time to import and the compliance costs for imports. The SOEs at times further outsource the inspection to other companies. Anecdotal evidence - gathered from interviewing companies in Indonesia - suggests that such limited supply of inspection agencies further increases the time it takes to comply with such a procedure.⁶

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 aiming to

⁶Consistent 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.

detect suspicious shipments at the border.⁷ As further evidence that this measure appear unnecessary, we find that Indonesia is the only country that requires PSI in Southeast Asia and among other middle-income countries.

Port of Entry Restrictions

The third measure relates 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 south-East Asia, compared to about 20% in Indonesia.

Compliance with National Standards

The final NTM is *compliance with national standards SNI* (B7), 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.

Besides being complex, the incidence of the compulsory certification procedure is also particularly widespread in Indonesia as it is applied to thousands of products in our sample period, which do not present major safety risks for consumers. These include several intermediate inputs, such as light bulbs, steel rods, and tires, which are used by firms rather than final consumers. As such the application of this measure appears to unnecessarily restrict trade for many of these goods.

3 Model

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

⁷Indeed our interviews with Indonesian officials suggest that the customs agency does not take into account the report of the PSI in their assessment of the risk of the shipment.

purpose of the model is to provide information about how the fixed order cost, shipping delays, and iceberg 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. \(2010\)](#), 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 the standard trade frameworks, in this model, the presence of fixed ordering costs and delivery lags and its relationship between observed firm behavior in terms of ordering frequency and inventory holdings make it particularly well-suited to estimate 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, q_j , is a function of price with a constant elasticity of substitution: $y_j = e^{\nu_j} p_j^{-\theta}$, where ν is drawn from a normal distribution with variance σ_ν , $N(0, \sigma_\nu)$.

Goods ordered at the beginning of the period arrive within the same period with probability $1 - \mu_I$, where subscript I denotes an order from an international supplier. 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—they depreciate 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.

Ending-period inventories are carried over to the next period net of depreciation.

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

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

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 , which is denominated in units of labor.

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,

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

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

$$s' = (1 - \delta) [s - q(p, s, \nu)]. \quad (4)$$

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

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

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

$$s' = (1 - \delta) [s + z - q(p, s, \nu)]. \quad (7)$$

where the difference in 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 its inventories are $s + z$. The value of the firm when it places an order is

$$J(s, \nu) = \max_z - \iota \omega z + (1 - \mu) V^N(s + z, \nu) + \mu V^O(s, \nu, z). \quad (8)$$

where ω is the purchase price of imports and ι denotes the advalorem iceberg 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

$$(1 + R)^{-1}(1 - \delta) \mathbb{E}_{\nu'} V_1(s', \nu') = \omega, \quad (9)$$

where V_1 is the derivative of the value function with respect to the inventory level. Firms are monopolistic competitors, so the pricing function has the usual constant markup specification,

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

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 it arrives in the current period is the price a markup over ω .

3.2 Identifying cost parameters

Now we describe how we combine data and model findings to decompose the effects of NTMs into delivery delays and fixed cost components in addition to standard ad-valorem iceberg costs.

We model the effect of NTMs on different margins of trade costs faced by importers: the fixed ordering cost (ϕ), shipping delays (μ), and ad-valorem costs (ι).

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

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

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

where $\beta_{i,j}$ is the effect of imposing the NTM j on cost parameter $i \in \{\phi, \mu, \iota\}$. Cost type i faced by domestic producers are denoted by i_D and a_i is the cost i faced by importers regardless of the NTMs, relative to their domestic counterparts.⁸ which can be written as the following in matrix notation,

$$COST_I = \mathbf{A} + COST_D + \beta NTM \quad (12)$$

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

⁸For example, tariffs are captured by a_i .

relationship of average moments as a function of cost parameters,

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

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

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

In the matrix, this can be written as

$$Moments_I = \Gamma COST_I \quad (14)$$

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

$$Moments_I = \Gamma \mathbf{A} + \Gamma COST_D + \Xi NTM \quad (15)$$

where $\Xi = \Gamma \beta$. These equations can be written as:

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

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

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

where Ξ is a function of Γ , \mathbf{A} and $COST_D$ denote the effect of underlying trade costs, regardless of the NTMs. We obtain the matrix Ξ using the product- and firm-level data, and use the relationship between parameters and these moments in the model (Γ) to obtain β . Once we have estimates of β we plug in the aggregated values of NTMs (coverage or frequency ratios) to arrive at the fixed ordering costs, shipping delays, and ad-valorem costs faced by the importing firms. It can also be seen that this approach outputs the parameter values for purely domestic firms as well, using Γ and the constants from (15). We later use this estimated relationship between the parameter values and NTMs (β matrix) to perform counterfactual exercises with different levels of NTMs.

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 do a product-level analysis since NTMs are imposed on products and we drop countries for which Indonesia has a free trade agreement since imports

from these countries are not subject to NTMs.⁹

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 the effects of all other NTMs.

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

where Y_{gt} can be import values or number of transactions in a year. This is the data counterpart to the equations (16b) and (16c). The NTM exposure variable $d_{j,gt}$ denotes the average share of HS10 products within HS6 category g that are subject to NTM j in year t , obtained by collapsing the monthly HS10-level binary NTM indicators to the HS6 \times year level using a simple mean. Import value is the total USD value of imports of a particular HS6 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 controls for other NTMs.

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 year-HS2-digit 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 year-HS-2 digit 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. Table 2, columns 1 and 2, present the results from the analysis. All four NTMs negatively affect import values and the number of transactions, but importantly, at varying economic and statistical intensities. While B7 (compliance with national standards) does not seem to affect import volume significantly, only C1 (pre-shipment inspections) and C3 (port of entry restrictions) have significant effect on import values, the traditional variable used to compute ad valorem equivalence in the literature, reducing it by 35% and 45%, respectively. On the other hand, B7 (compliance with national standards), B14 (import approval requirements), and C1 (pre-shipment inspections) primarily affect the number of transactions, reducing it by 26%, 34% and 68% (column 2), respectively. These results are robust to alternative specifications, namely omitting the tariff

⁹While the information on import values and ordering frequency come from our customs data which we can aggregate to product level, the information on inventories come from plant-level manufacturing survey data which we cannot aggregate to product level.

control and using pre-analysis-period (2010–2013) weights when aggregating NTMs from the HS10 to the HS6 level (Appendix Tables 8 and 9).

4.2 Effect of NTMs on Firm Inventories

Now we discuss how we estimate the effect of NTMs on inventory holdings. Unlike estimating the effects on import values and number of transactions, we consider the NTM exposure and inventories at the firm level since inventories are not available at the product level.

We begin by summarizing the monthly binary NTM variables at the annual level in equation 18 using monthly imports as the weight:

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

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 and not by their outputs. Therefore, we use the 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 the survey of manufacturing plants, described in Section 2.2, using HS-codes concordance with 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.¹⁰ Then we use the cross-industry purchases in 2016 as the weights to construct a measure of NTMs on firms' inputs using equation 19:

$$NTM_{st}^{in} = \sum_r \omega_{sr,2016} NTM_{rt}^{out} \quad (19)$$

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 by using imports as weights to convert HS level NTMs to IO code level. After constructing the relevant independent variables, we run the following specification which is the data counterpart of the inventory

¹⁰The change in the aggregation level is such that we go from 278 KBLI industries to 73 input-output industries.

equation (16a).

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

where S_{ft} is the firms' end-of-year inventories to total purchase ratio. 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 the vector of controls for other NTMs. We also control for firm and year fixed effects, shown above as ζ_f and ζ_t , respectively.

The estimation results are detailed in the last column of Table 2. The analysis reveals that two out of the four NTMs — requirements for product standards (B7) and import approvals (B14)— significantly and positively impact inventories, with import approval 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.

5 Model Quantification

Here, we 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 . We, however, 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 set to be quarterly, therefore the discount factor is set $(1 + R)^{-1} = 0.96^{1/4}$ to correspond to 4% 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 be 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 iceberg cost (ι), importers' fixed order cost (ϕ_I), and import

delivery delays, (μ_I) . Each simulation is denoted by (ϕ_I, μ_I, ι) which are randomly drawn in the following way: 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 1.24.¹¹ We draw 500 combinations of these costs. We then run the specification in (14) using the model simulated data using importers' total inventory holdings, the average frequency of orders, and total purchases in each steady state.

The results are presented in Table 4. 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 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 iceberg costs. It is important to note that while in the literature there are many studies on how iceberg costs affect imports, in this paper we bring in additional costs firms face such as fixed order costs and delivery delays that can show up in the number of times firms order and how much inventories they hold.

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 6 quantify how each NTM maps into economically meaningful cost components using the methodology outlined in Section 3.2.

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 fixed ordering costs firms face, by 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 iceberg cost cannot capture its impact. PSI (C1) requires shipments to be inspected at the port of departure from the exporting country before leaving for Indonesia. Since only

¹¹The range for ϕ_I is based on estimates of order costs in [Alessandria et al. \(2010\)](#), 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](#)).

two SOEs in Indonesia have the authority to carry out these inspections, these measures increase the compliance costs in terms of both time and money 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, making inventory replenishment less responsive to short-run shocks. 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%.¹²

NTMs also influence delivery delays faced by firms. We find that import authorization requirements have the largest increasing effect on delivery delays (25%), with product standard requirements 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 approval 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 approval). Oftentimes, companies do not hear back about import approval, or their requests get lost. Import authorization, therefore, tends to increase both the fixed ordering costs as well as delays in deliveries. Product standard requirements 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 those ports. In our estimation, this is identified by the combination of this NTM reducing ordering frequency while having no significant effect on inventories. Table 4 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 effect of NTM operates

¹²The effects are calculated as $(exp(\beta) - 1) * 100$.

through increased fixed ordering costs but also faster shipping times.

The standard approach overlooks these NTM effects, capturing only iceberg costs and not their impact on fixed costs or delivery delays reflected in additional data moments. We also estimate the impact of NTMs on iceberg 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 6). 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. On the contrary, product standards requirements lead to a small reduction in ad valorem trade costs, which shows how compliance with standards signals higher quality, consistent with the findings of [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 iceberg trade cost equivalence. The robustness of these cost decompositions to alternative values of key structural parameters (σ and δ) is examined in Appendix B.

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 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.

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 iceberg 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. \(2023\)](#). Iceberg costs are set to 5 percent. We then incorporate the estimated effects of NTMs on these cost components from Section 5.2, summarized in Table 6, to construct products 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 iceberg costs.

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

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.¹³

Figure 2 reports the dynamic responses of imports, the fraction of firms placing orders, retail prices, and inventories available for sales. 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 is muted, leading to a sharper reduction in inventories available for sale. This amplifies the decline in imports 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.

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 iceberg costs, have only minor effects on these dynamics. The responses of inventories, imports, and prices closely track those

¹³The 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).

in the baseline, indicating that iceberg 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 sales. 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.

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 iceberg costs, have relatively modest effects on inventory dynamics. Since iceberg 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 (*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.

7 Heterogeneous Effects of NTMs Across Product Categories

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.¹⁴

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.

After assigning each input sector to a single BEC category, we 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

$$NTM_{s,t}^b = \sum_r \omega_{sr} \cdot NTM_{r,t} \cdot \mathbf{1}_{\{r \in b\}}, \quad (21)$$

¹⁴Some 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 3 contains the results.

The results reveal meaningful heterogeneity across end-use categories. Comparing Tables 2 and 3 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 ($C1$) have strong negative effects on both imports and ordering frequency for intermediate goods, indicating that their average impact is largely driven by production inputs. 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 behavior depending on the end-use of the good, highlighting that average estimates mask important underlying heterogeneity.

7.2 Implied Cost Decomposition Across Product Categories

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 iceberg costs across end-use categories.

The results reveal systematic differences in how NTMs translate into underlying frictions. Product standards ($B7$) increase fixed ordering costs for consumption and intermedi-

ate goods, with negligible effects for capital goods. However, the associated delivery delays are concentrated in consumption goods, while being small or negative for intermediates. This indicates that 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 are concentrated in intermediate goods, while they are negative for capital 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 across categories, 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 iceberg 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 3.

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, leading to heterogeneous effects on trade flows, inventories, and adjustment dynamics. This highlights that aggregate measures of NTMs may obscure important variation in their economic consequences, reinforcing the need for a disaggregated approach to understanding trade policy.

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 iceberg 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 trade frictions affect production and supply chains. This underscores the importance of moving beyond common trade costs to understand the sectoral and compositional effects of policy interventions.

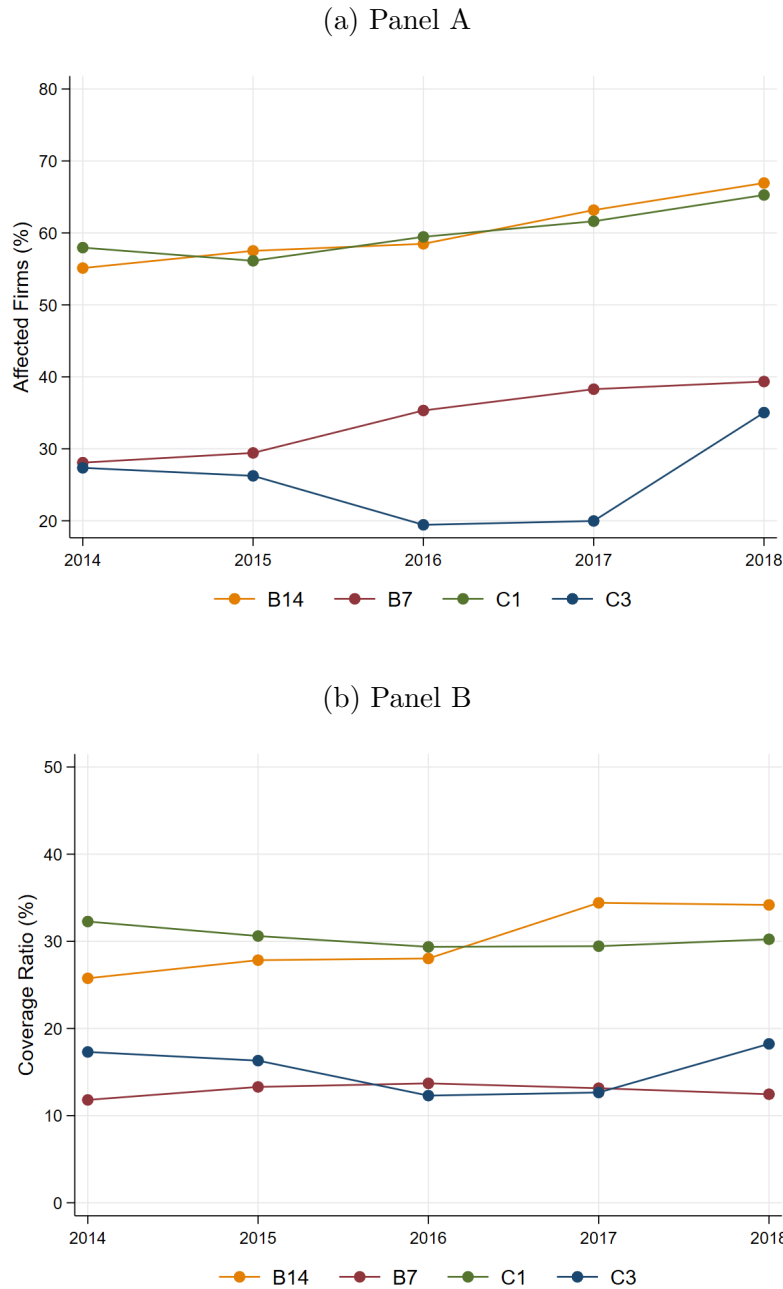
More broadly, the framework developed in this paper provides a new approach for evaluating trade policy in environments with inventories and lumpy adjustment. By linking observed firm behavior to underlying cost structures, it allows researchers to study how different policies affect not only the level 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.

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.

9 Figures and Tables

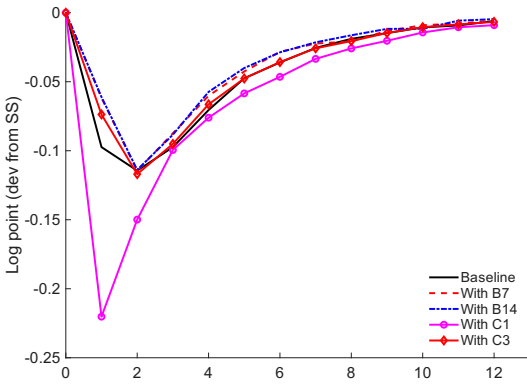
Figure 1: Share of total imports and percentage of firms affected by NTMs



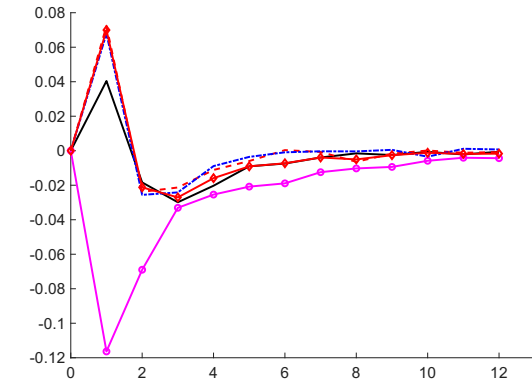
Notes: Panel (a) plots the share of importing firms affected by the four different NTMs under study. Panel (b) plots the coverage ratio (share of total imports affected by an NTM) for the four different NTMs under study. Source of data is Indonesian firm-level customs data from 2014 to 2018 and the time-varying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

Figure 2: Temporary Increase in Delivery Times by 10 Days

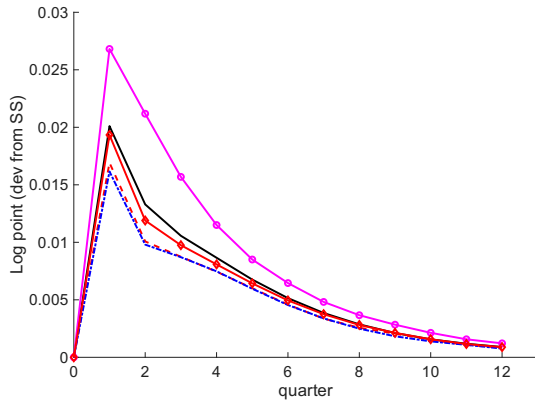
(a) Imports



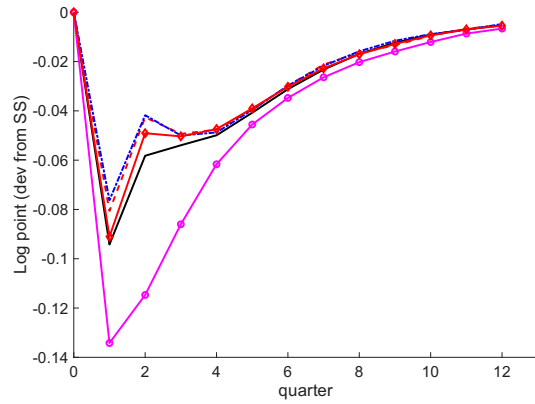
(b) Firms Ordering



(c) Retail Price



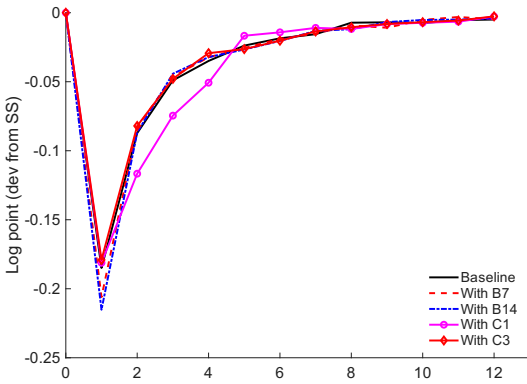
(d) Inventories (available for sales)



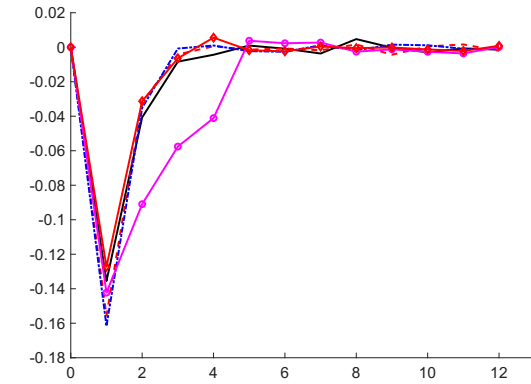
Notes: The NTM B7 is the requirement to comply with National Product Standards. B14 is import authorization requirements. C1 is requirement for shipments to be inspected at the port of departure. Lastly, C3 is restriction of entering the country through specific ports.

Figure 3: Temporary Tariff Increase by 1 Percent

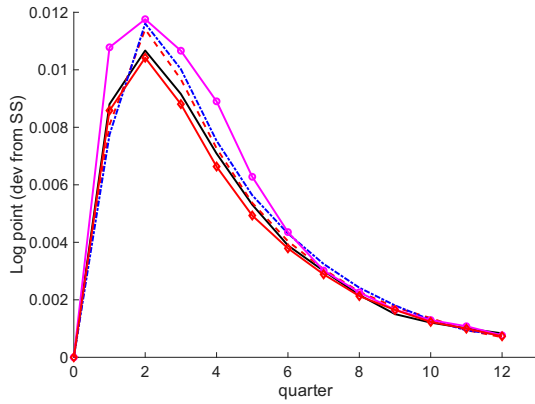
(a) Imports



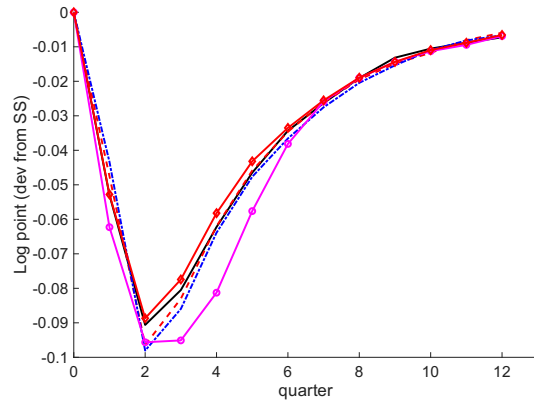
(b) Firms Ordering



(c) Retail Price



(d) Inventories (available for sales)



Notes: The NTM B7 is the requirement to comply with National Product Standards. B14 is import authorization requirements. C1 is requirement for shipments to be inspected at the port of departure. Lastly, C3 is restriction of entering the country through specific ports.

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%
B83 Certification requirement	7%
B82 Testing requirement	8%
B81 Product registration requirement	6%

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

Table 2: Data Effects of NTMs on Import values, frequency of transactions, and inventory holdings

Dep. var.	ln(imports)	ln(#transactions)	ln (Inventory/Purchases)
	(1)	(2)	(3)
d_{B7}	-0.01 (0.28)	-0.26*** (0.09)	0.22** (0.11)
d_{B14}	-0.02 (0.19)	-0.34*** (0.07)	0.30* (0.18)
d_{C1}	-0.35* (0.21)	-0.68*** (0.08)	0.06 (0.13)
d_{C3}	-0.45** (0.22)	0.13 (0.08)	-0.08 (0.06)
Tariff	-7.27*** (1.46)	0.41 (0.60)	0.00 (0.01)
ln (imports)		0.44*** (0.01)	
Other NTM control	✓	✓	
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) \times year panel of total imports into Indonesia. 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 \times year fixed effects. Additional controls include tariff exposure and normalized NTM intensity shares for TBT, SPS, quality-control, price-control, and export measures (*Other NTM controls*). Column 2 additionally controls for ln(imports). Standard errors are clustered at the HS6 level. Column 3 uses a firm \times year panel from the Annual Manufacturing Survey (2014–2018). NTM exposure is measured as IO-weighted averages of HS10-level NTM incidence measures at the firm level. 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, quality-control, and price-control measures (*Other NTM controls*). Standard errors are clustered at the firm level.

Table 3: Data Effects of NTMs by End-Use Category

	ln(imports) (1)	ln(#transactions) (2)	ln(Inv/Purch) (3)
<i>d_{B7}</i> (National Product Standards)			
<i>Capital</i>	-0.08 (0.56)	0.45 (0.37)	-0.88 (2.80)
<i>Consumption</i>	0.15 (0.59)	-0.45 (0.31)	0.25* (0.13)
<i>Intermediate</i>	-0.14 (0.32)	-0.34* (0.18)	0.22 (0.18)
<i>d_{B14}</i> (Import Authorization Requirements)			
<i>Capital</i>	-0.30 (0.41)	-1.16*** (0.33)	6.93 (8.48)
<i>Consumption</i>	-0.56* (0.31)	-0.46** (0.19)	0.24 (0.68)
<i>Intermediate</i>	0.05 (0.21)	-0.17 (0.11)	0.32* (0.19)
<i>d_{C1}</i> (Pre-Shipment Inspections)			
<i>Capital</i>	0.12 (0.37)	-0.36 (0.32)	-6.94 (8.57)
<i>Consumption</i>	-0.62 (0.44)	-0.94*** (0.29)	0.60 (0.68)
<i>Intermediate</i>	-0.48* (0.27)	-0.73*** (0.15)	0.01 (0.14)
<i>d_{C3}</i> (Port-of-Entry Requirements)			
<i>Capital</i>	-0.40 (0.60)	-0.23 (0.43)	8.14 (8.31)
<i>Consumption</i>	-0.32 (0.28)	-0.23 (0.17)	-0.13 (0.12)
<i>Intermediate</i>	-0.55 (0.37)	-0.11 (0.21)	-0.06 (0.06)
Tariff	-6.75*** (1.49)	-2.56*** (0.95)	—
Other NTM controls	✓	✓	
HS4 FE	✓	✓	
HS2×Year FE	✓	✓	
Year FE			✓
Firm FE			✓
<i>N</i>	17347	17347	85945
<i>R</i> ²	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 main Table 2.

Table 4: Model Implied Relationship between Parameters and Moments

Dep var:	ln(inventory-sales)	ln(order freq)	ln(imports/domestic)
	(1)	(2)	(3)
ln(foreign fixed cost/revenue)	0.16	-0.51	-0.22
ln(delivery delay)	0.79	0.33	-0.43
ln(iceberg 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.

Table 5: Trade Costs in the Presence of NTMs

	Fixed order cost	Delivery Delay	Iceberg cost
Baseline	12	45	1.05
Product Standard (B7)	22	53	1.02
Import Authorization (B14)	27	56	1.01
Pre-shipment Inspections (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 cost are expressed as proportion of average quarterly revenue in the baseline version. Delivery delays are expressed in days.

Table 6: Estimated Effects of Non-Tariff Measures on Various Cost Types

Cost	NTM			
	Product standards (B7)	Import authorization (B14)	Pre-ship insp (C1)	Entry port req. (C3)
Fixed order cost	0.61	0.81	1.18	0
Delivery delays	0.15	0.22	-0.24	0
Iceberg 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 iceberg trade costs. This is 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 0.16 log points

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

Cost	NTM			
	Product standards (B7)	Import authorization (B14)	Pre-ship insp. (C1)	Entry port req. (C3)
<i>Panel A. Capital goods</i>				
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
<i>Panel B. Consumption goods</i>				
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
<i>Panel C. Intermediate goods</i>				
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 iceberg 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 .

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Appendix

A Robustness: Empirical Results

The baseline findings in Table 2 are robust to alternative specifications, as shown in Table 8. Columns 1–2 omit the tariff control and find that the estimated effects of all four NTMs on both import values and transaction frequency are virtually unchanged in sign, magnitude, and statistical significance relative to the main results. In particular, pre-shipment inspections (C1) and port-of-entry restrictions (C3) continue to exert significant negative effects on import values, while compliance with national standards (B7), import authorization requirements (B14), and pre-shipment inspections (C1) retain their large and precisely estimated negative effects on the number of transactions. Columns 3–4 create an alternative exposure measure to non-tariff measures, weighing the non-tariff measures by the pre-period importance of the imported products in total imports during 2010–2013, holding these weights fixed across years. Under this alternative construction, the point estimates are again stable: the transaction frequency results are nearly identical to those in the baseline, and the import value results are directionally consistent, though the effect of C1 loses statistical significance, likely reflecting attenuation of some products from the pre-period weighting. Taken together, these robustness checks confirm that the heterogeneous effects of disaggregated NTMs on import values and transaction frequency documented in Table 2 are not driven by the inclusion of contemporaneous tariff controls or by potential endogeneity in NTM assignment.

Table 8: Robustness

Dep. var.	ln(imports)	ln(#transactions)	ln(imports)	ln(#transactions)
	(1)	(2)	(3)	(4)
d_{B7}	0.05 (0.28)	-0.27*** (0.09)	-0.18 (0.26)	-0.27*** (0.09)
d_{B14}	0.04 (0.19)	-0.34*** (0.07)	-0.00 (0.18)	-0.34*** (0.06)
d_{C1}	-0.38* (0.21)	-0.68*** (0.08)	-0.24 (0.20)	-0.61*** (0.07)
d_{C3}	-0.42* (0.22)	0.12 (0.08)	-0.36* (0.20)	0.08 (0.08)
Tariff	—	—	-6.97*** (1.49)	0.43 (0.61)
ln(imports)		0.44*** (0.01)		0.44*** (0.01)
Other NTM controls	✓	✓	✓	✓
Tariff control			✓	✓
Init.-yr. import weights (2010–2013)			✓	✓
HS4 FE	✓	✓	✓	✓
HS2×Year FE	✓	✓	✓	✓
N	17,505	17,505	17,481	17,481
R^2	0.55	0.85	0.55	0.85

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table shows robustness results for (17). Columns 1–2 correspond to exercise (c): the tariff control is omitted. Columns 3–4 replace NTM variables with 2010–2013 import-weighted aggregates: HS10-level NTMs are collapsed to HS6×year using the sum of each HS10 product’s import value over 2010–2013 as weight (normalised to the HS6-level total), fixed across years. The tariff control is retained in columns 3–4. Standard errors clustered at the HS6 level.

Table 9: Robustness: Inventory Holdings on Aggregated NTMs

Dep. var.: ln (Inventory/Purchases)	(1)	(2)	(3)
d_{B7}	0.221** (0.111)	0.234** (0.112)	0.231** (0.111)
d_{B14}	0.299* (0.177)	0.292* (0.177)	0.297* (0.177)
d_{C1}	0.063 (0.127)	0.054 (0.131)	0.039 (0.125)
d_{C3}	-0.077 (0.056)	-0.075 (0.056)	-0.074 (0.056)
Tariff control	No	✓	✓
Export NTM count (n_{exp})	No	✓	No
Price-ctrl NTM count (n_{qc})	✓	✓	No
Other NTM controls	✓	✓	✓
Firm FE	✓	✓	✓
Year FE	✓	✓	✓
N	85,945	85,945	85,945
R^2	0.786	0.786	0.786

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table reports estimates of the effect of NTMs on inventory holdings relative to purchases (column 3 of Table 2) under alternative control specifications. All columns use a firm \times year panel from the Annual Manufacturing Survey (2014–2018) with firm and year fixed effects and standard errors clustered at the firm level. The baseline specification includes ln(raw materials), ln(sales), an IO-weighted tariff, and NTM intensity counts for SPS, TBT, quality-control (n_{qc}), and price-control measures as controls (*Other NTM controls*). Column 1 omits the IO-weighted tariff. Column 2 adds the count of upstream export-related measures (n_{exp} , P-chapter NTMs). Column 3 drops the price-control NTM count (n_{qc} , E-chapter NTMs).

Table 9 examines the sensitivity of the baseline inventory result to alternative control specifications. The baseline includes exposure to input tariffs and other NTM categories (SPS, TBT, quality control, and price-control measures) as controls. Column 1 omits the input tariff control. The inclusion or exclusion of tariffs should not affect the identification of the B7 and B14 effects on inventories if the NTM variables are orthogonal to tariff expo-

sure conditional on firm fixed effects — which is what we find. Column 2 adds the count of export-related measures facing a firm’s input suppliers, to address the concern that upstream export restrictions may alter domestic input availability and thereby affect inventory holdings. Finally, Column 3 drops the price-control NTM count (n_qc), which captures E-chapter measures such as price-band systems and reference prices on inputs since such measures could in principle reduce input price uncertainty in ways that partially overlap with the cost channels we attribute to B7 and B14. We verify that their inclusion does not drive our results. Across all three specifications, the estimated effects of pre-shipment inspection requirements (B7) and import authorization requirements (B14) on inventory holdings remain positive and statistically significant.

B Model Robustness

This appendix evaluates the robustness of the model-based cost decomposition to alternative values of key structural parameters. The decomposition relies on the mapping between observed reduced-form coefficients and underlying cost parameters, governed by the model-implied matrix Γ . Changes in parameters such as σ and δ affect this mapping and, therefore, the inferred cost matrix β .

Our approach proceeds in two steps. First, for each parameter of interest, we compute the elasticity of the partial-equilibrium coefficients (the elements of $\Xi = \Gamma\beta$) with respect to that parameter. Second, we use these elasticities to update the mapping from Ξ to β , thereby tracing out the implied range of cost estimates while holding fixed the empirical moment matrix $\Gamma_{\beta,2}$ obtained in the data. This isolates the role of model discipline (through Γ) from the empirical estimates of reduced-form effects.

B.1 Robustness to σ

We begin by varying the demand elasticity σ , which governs firms’ pricing responses and therefore affects the sensitivity of observed moments to underlying cost parameters.

Table 10 reports the elasticity of the partial-equilibrium coefficients with respect to σ . These elasticities capture how changes in σ alter the mapping between moments (inventories, frequency, imports) and cost parameters.

Table 11 then reports the implied range of the estimated cost matrix β under alternative values of σ . Each entry is presented as $[x \ y]$, where x is the implied element of the cost matrix β at $\sigma = 1.25$ and y is the corresponding element at $\sigma = 1.75$.

Across all specifications, the decomposition is highly stable. The ranking of NTMs across

cost components—fixed ordering costs, delivery delays, and iceberg costs—remains unchanged, and the magnitudes of the estimates vary only modestly. This indicates that the identification of different cost channels is not driven by a particular calibration of demand elasticity.

Table 10: Elasticity of Partial-Equilibrium Coefficients to σ

	Inventory-sales	Frequency	Imports
Fixed cost	-0.428	-0.306	-0.772
Delay	0.235	0.415	0.627
Iceberg cost	.	.	0.028

Notes: Elasticity is the log change in absolute coefficient over the log change in σ . Entries are left missing when $|b/se| < 1.96$.

Table 11: Range of Estimated Cost Effects Under Alternative Values of σ

Cost	NTM			
	Product standards (B7)	Import authorization (B14)	Pre-ship insp. (C1)	Entry port req. (C3)
Fixed order cost	[0.573 0.644]	[0.757 0.851]	[1.116 1.235]	[0.000 0.000]
Delivery delays	[0.160 0.151]	[0.223 0.211]	[-0.255 -0.226]	[0.000 0.000]
Iceberg cost	[-0.025 -0.025]	[-0.034 -0.034]	[0.024 0.024]	[0.057 0.057]

Notes: Each entry is reported as $[x \ y]$, where x is the implied element of the cost matrix β at the lower value of σ and y is the corresponding element at the higher value. The empirical moment matrix $\Gamma_{\beta,2}$ is held fixed throughout. For coefficients whose elasticity is undefined due to near-zero benchmark estimates, the corresponding cost component is fixed at its benchmark value.

B.2 Robustness to Inventory Depreciation

We next consider the inventory depreciation rate δ , which governs the cost of holding inventories and therefore directly affects the inventory–frequency trade-off in the model.

Table 12 reports the elasticity of the partial-equilibrium coefficients with respect to δ . As with σ , these elasticities capture how changes in δ modify the mapping from observed moments to cost parameters.

Table 13 presents the corresponding range of implied cost estimates. Each entry is again reported as $[x \ y]$, where x corresponds to $\delta = 0.06$ and y to $\delta = 0.04$. Note that the ordering reflects the way the simulations are reported, with δ decreasing from 0.06 to 0.04 across entries.

The results confirm that the decomposition is robust to variation in inventory depreciation. The relative importance of fixed costs, delivery delays, and iceberg costs across NTMs is preserved, and the quantitative changes remain small. This reflects the fact that while δ affects the level of inventories, it does not materially alter the distinct mapping of moments to different cost components emphasized by the model.

Table 12: Elasticity of Partial-Equilibrium Coefficients to δ

	Inventory-sales	Frequency	Imports
Fixed cost	-0.946	0.417	0.990
Delay	0.464	0.721	0.921
Iceberg cost	.	.	-0.055

Notes: Elasticity is the log change in absolute coefficient over the log change in δ . Entries are left missing when $|b/se| < 1.96$.

Table 13: Range of Estimated Cost Effects Under Alternative Values of δ

Cost	NTM			
	Product standards (B7)	Import authorization (B14)	Pre-ship insp. (C1)	Entry port req. (C3)
Fixed order cost	[0.585 0.639]	[0.774 0.845]	[1.116 1.253]	[0.000 0.000]
Delivery delays	[0.164 0.132]	[0.228 0.187]	[-0.175 -0.348]	[0.000 0.000]
Iceberg cost	[-0.025 -0.025]	[-0.034 -0.034]	[0.024 0.024]	[0.057 0.057]

Notes: Each entry is reported as $[x \ y]$, where x is the implied element of the cost matrix β at $\delta = 0.06$ and y is the corresponding element at $\delta = 0.04$. The empirical moment matrix $\Gamma_{\beta,2}$ is held fixed throughout. For coefficients whose elasticity is undefined due to near-zero benchmark estimates, the corresponding cost component is fixed at its benchmark value.