Transparency as Trade Policy: Evidence from Notification Timing in TBTs

Irene Iodice

Bielefeld University*

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Abstract

This paper quantifies the benefits of timely WTO notification of technical barriers to trade (TBTs). Using a new dataset linking TBT timelines to French firm-level exports, I show that advance notice halves the decline in export participation and prevents small-firm exits. Timely disclosure spares firms a shock equivalent to a one-year tariff four times larger than the TBT's trade cost. A model with firm heterogeneity and policy uncertainty explains how early notification reduces compliance-cost uncertainty and discourages exit. These findings highlight transparency as a key factor in mitigating trade disruptions from new regulations.

Keywords: Trade policy uncertainty · Non-tariff Barrier · WTO

*Contact information: irene.iodice@uni-bielefeld.de.

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1 Introduction

Over the last decades, technical regulations have become increasingly important, with exporters from various countries identifying them as a major obstacle to international trade (OECD, 2005; EU Commission, 2019).[1] Meeting the technical regulations of foreign markets can be challenging for exporters, as it requires a detailed understanding of market requirements and the costs associated with demonstrating compliance. If access to this information is restricted, domestic regulations can act as a hindrance to trade for foreign companies. Despite a consensus in the literature that countries can misuse technical regulations to protect their domestic industries (Trefler, 1993; Lee and Swagel, 1997; Beverelli et al., 2014; Orefice, 2017; Herghelegiu, 2018; Mei, 2018; Grossman et al., 2021), little is known about the role of transparency in these policies. This is surprising given that exporters mostly complain about procedural obstacles associated with technical measures rather than the content of these regulations (International Trade Center, 2016). For instance, UNCTAD (2015) documents that while exporters can easily access the applicable tariff rates for a particular product in a target market, the situation is different when they are searching for details about nontariff measures (NTMs). This is due to a lack of systematic and comparable information, resulting in substantial uncertainties surrounding NTMs.

The World Trade Organization (WTO) framework, specifically the Agreement on Technical Barriers to Trade (TBT), mandates transparency procedures intended to mitigate such informational frictions. Governments are required to notify proposed technical regulations by publishing official documents detailing the requirements, ideally in advance, allowing trade partners time to understand and prepare. This notification process aims to provide the necessary information for a predictable trading environ-

[1] The EU Trade and Investment Barriers Report of 2019 documents that technical barriers to trade are the second most reported trade obstacles faced by EU companies in third countries, being cited more often than "tariffs and equivalents and quantitative restrictions". Similarly, surveys of exporting firms across OECD countries show that "technical measures and customs rules and procedures ... are [consistently] among the five most reported categories of non tariff [trade] barriers" (OECD 2005, p. 24).

ment where firms know how to comply when a regulation enters into force. Yet, adherence to providing this documentation before implementation varies. This paper asks: What is the economic value generated when this notification process functions as intended? Specifically, I quantify how the presence of prior notification – defined here as the official documentation being available before the TBT's enforcement date – affects export outcomes compared to situations where regulations are enforced without such advance notice. Does having access to the "rulebook" beforehand significantly reduce the trade-dampening effects commonly associated with TBTs?

To investigate this question, I construct a novel dataset linking WTO TBTs challenged via specific trade concerns (STCs) from 1995 to 2011 with detailed French firm-level export data (1995-2007). By reconstructing the precise implementation and notification timelines, I distinguish between measures implemented with prior official notification versus those implemented without such advance documentation. I find that a substantial share (roughly 40%) of challenged TBTs lacked prior notification. My central finding is that prior notification provides significant economic value. Having access to the official TBT documentation before its enforcement substantially reduces the associated disruptions to export activity. Specifically, prior notification mitigates the negative impact on export participation by approximately 4 percentage points compared to TBTs implemented without prior notice.

Motivated by this empirical pattern, I develop a theoretical framework (in the spirit of Dixit et al. (1994) and Handley and Limão (2017)) focusing on firm heterogeneity and policy uncertainty. The model highlights how receiving notification before implementation clarifies the requirements and reduces uncertainty about the costs and methods of compliance. Knowing the rules of the game narrows the range of possible compliance cost outcomes, lowering the real-option value of waiting for clarity. This encourages firms, particularly less productive ones, to undertake necessary adaptations and maintain their presence in the export market, rather than pausing or exiting temporarily while seeking information.

I test these predictions using a differences-in-differences strategy at the product × firm × destination level, exploiting the staggered introduction of TBTs across markets and time. The core of the strategy involves comparing export dynamics following TBTs implemented with prior notification versus those implemented without.

The estimates confirm the significant value derived from prior notification. TBTs implemented after notification documents were available result in a markedly smaller decline in export participation (roughly 3%) compared to the larger decline (roughly 7%) observed when TBTs enter force without prior notice. The benefit of having prior documentation is particularly pronounced in reducing temporary market exits (by 6 percentage points compared to the unnotified group) and is stronger for smaller firm. I quantify this value further: receiving timely notification is economically equivalent to avoiding a temporary tariff increase that is four times the magnitude of the initial TBT's implicit trade barrier. This underscores the critical importance of the notification process—as a means of providing timely compliance information—in shaping the ultimate trade effects of TBTs.

Relation to the Existing Literature. This study contributes to several strands of research. First, it informs the literature on how non-tariff measures (NTMs), particularly TBTs, shape firm-level export decisions. While numerous studies find that TBTs often raise fixed or sunk costs, reducing trade along the extensive margin (Bao and Qiu, 2012; Fontagné and Orefice, 2018; Beghin et al., 2015), and some show potential trade-enhancing effects via standard harmonization (Schmidt and Steingress, 2022), our distinct contribution is to demonstrate that the method and timing of TBT introduction critically mediate these effects. We isolate the impact of procedural transparency (notification) itself, showing it has substantial economic value independent of the regulation's content, addressing exporter concerns about informational and procedural barriers.

Within this literature, our work builds upon, yet significantly differs from, Fontagné and Orefice (2018). Fontagné and Orefice (2018) pioneered the use of WTO STC data

to identify potentially restrictive TBTs and estimated their average negative impact on French export participation (around 5%). While their work established that challenged TBTs are, on average, trade-restrictive, our paper goes further by dissecting this effect based on adherence to WTO notification procedures. Our primary focus is not just whether a challenged TBT is restrictive, but how much of that restriction is associated with the lack of timely notification. Our key contribution relative to Fontagné and Orefice (2018) is thus threefold: (1) We explicitly disentangle the impact of notified versus unnotified TBTs, isolating the effect of the notification process itself. (2) We provide direct evidence for the uncertainty channel as a core mechanism, linking lack of notification to increased temporary exits and entry deterrence via a real-options framework, whereas Fontagné and Orefice (2018) primarily interpreted the average effect through a fixed cost lens. (3) We quantify the economic value of timely notification specifically, demonstrating its large magnitude in tariff equivalent terms.

Second, this paper contributes to the broader literature on the value of transparency in trade policy. While earlier studies often relied on qualitative indices or general provisions in trade agreements (Francois, 2001; Helble et al., 2009; Lejárraga and Shepherd, 2013), and more recent work like Ing et al. (2018) constructed indices based on notification propensity, our contribution lies in analyzing the impact of the actual timing of specific notifications relative to implementation at a granular level. By leveraging our unique timeline data for individual TBTs, we directly measure the value of predictability—a core dimension of transparency emphasized by Helble et al. (2009) but rarely quantified directly in the context of NTM implementation shocks.

Finally, the paper adds to the literature on trade policy uncertainty (TPU). Seminal real-options models (Bernanke, 1983; Dixit et al., 1994) applied to trade, often focusing on tariff uncertainty (Handley and Limão, 2015, 2017; Carballo et al., 2018; Alessandria et al., 2019; Liu and Ma, 2020; Coelli, 2022), show that unpredictability dampens trade and investment. Our contribution is to extend this framework squarely to NTMs, specifically TBTs, which often entail significant fixed compliance costs (Grossman et al.,

2021; Macedoni and Weinberger, 2022). We demonstrate empirically that the absence of timely notification for a new TBT acts as a potent, albeit subtle, source of TPU. This lack of advance warning effectively widens the perceived variance of compliance costs, increasing the option value of waiting and thereby depressing export participation. We thus identify a specific, policy-amenable mechanism (timely notification) through which NTM-related uncertainty can be mitigated.

The remainder of the paper is organized as follows. Section 2 provides institutional background on the WTO's transparency provisions and describes how I define (non)notification in practice. Section 3 discusses the construction of my dataset on French exporters and the compilation of specific trade concerns (STCs). Section 4 lays out a partial-equilibrium model of exporting under uncertainty, emphasizing how timely notification lowers the variance of future compliance costs. Section 5 details the empirical strategy, and Section 6 presents the main results on how unnotified TBTs induce temporary disruption and differential exit among smaller firms. Section 7 and Section 8 explore additional mechanisms and heterogeneity, while Section 9 quantifies the impact in terms of a tariff equivalent. Section 10 concludes with implications for NTM policy and WTO notification procedures.

2 Institutional Framework

The WTO Agreement on Technical Barriers to Trade (TBT) grants members the right to implement technical regulations to achieve legitimate policy objectives, such as ensuring import quality, protecting human health or the environment, safeguarding national security, or preventing deceptive practices, even if these regulations deviate from international standards. However, this right is subject to crucial disciplines designed to prevent protectionism. Measures must not arbitrarily or unjustifiably discriminate between countries, nor should they be more trade-restrictive than necessary to fulfill a

legitimate objective.[2]

A cornerstone of these disciplines is procedural transparency. To ensure a predictable trading environment, the TBT Agreement obliges governments to announce proposed technical standards to international partners in advance. This is done by issuing a "Notification" – a document detailing the new regulation – ideally allowing a 60-day comment period before adoption for trading partners to review, inquire, and adapt.[3]

If a WTO member believes these principles, including the transparency requirements, have not been respected, it can challenge the measure by raising a Specific Trade Concern (STC) at the WTO TBT Committee. Analysis of these STCs reveals a crucial pattern: while the stated objectives of challenged TBTs are often legitimate (e.g., health, safety, environment, see Figure 1a), the primary motivations for raising concerns frequently revolve around procedural flaws, particularly issues of transparency and lack of information (Figure 1b).[4] This highlights that the way a measure is implemented can be as contentious as its substance.[5]

Consider Mexico's 1998 ban on chlorofluorocarbons (CFCs) in refrigerators and air conditioners. While aligning with international environmental goals,[6] the ban was enacted under a state of emergency on September 22nd but only notified to the WTO on October 12th, post-implementation.[7] Consequently, the US raised an STC in November 1998, questioning the emergency justification and highlighting the resulting uncertainty for exporters regarding compliance procedures, such as the lack of accredited

[2]The TBT Agreement explicitly states: "Members shall ensure that technical regulations are not prepared, adopted or applied with a view to or with the effect of creating unnecessary obstacles to international trade." (Art. 2.2)

[3]A notification is "a transparency obligation requiring member governments to report trade measures to the relevant WTO body if the measures might have an effect on other Members" (World Trade Organization, 2017).

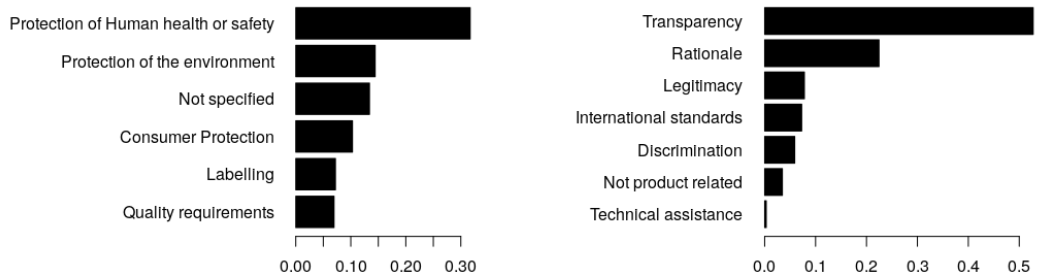
[4]Following the ITC survey (2016), we group transparency" withmissing information" and "unreasonable time" to represent procedural implementation flaws.

[5]Based on interviews with trade representatives, Holzer (2019) distinguishes STCs challenging how a measure was implemented from those challenging its content, underlining the practical relevance of procedural issues.

[6]The Montreal Protocol (1989, strengthened in the 1990s) aimed for a global CFC phase-out.

[7]Notification identifier: G/TBT/Notif.98.485.

Figure 1: Most frequent Objectives and Motivations of STCs



(a) Objectives (b) Motivations

Notes: The STC database encompasses TBTs, each associated with one or more stated objectives or motivations. In this context, an "occurrence" refers to a specific pairing of an STC with its corresponding objective(s) or motivation(s). The dataset records a total of 598 and 478 such occurrences. Within the category of Transparency, I have included instances of "unreasonable time" and "missing information." For the Rationale category, instances of "Unnecessary barriers to trade" have been consolidated. Additionally, the category of Discrimination has been expanded to incorporate instances of "Differential treatment."

testing labs.[8]

This example underscores how deviations from the standard notification process can create significant trade friction. Motivated by the prevalence of transparency-related STCs and cases like the Mexican CFC ban, this paper focuses on the value generated by adhering to notification timelines. We leverage the codified WTO procedure to identify instances of lack of transparency. Specifically, we define this as occurring when a country adopts and enforces a TBT without issuing a formal Notification prior to the enforcement date. We refer to such instances as TBTs introduced "by surprise."

3 Data and Stylized Facts

This section presents the data and describes the construction of a new dataset that recovers the implementation timelines of contested technical barriers to trade (TBTs) at the WTO. I first outline the limitations of the WTO's Specific Trade Concerns (STC)

[8]The US delegate stated: "She questioned the nature of the emergency... US exporters were uncertain about how to comply with the regulation." (G/TBT/M/14, par. 35)

database in identifying notification and enforcement dates. I then detail how I supplement this with regulatory documents to track the timing of TBTs. The resulting dataset is linked to French firm-level export and tariff data. I conclude with stylized facts on the prevalence and distribution of unannounced TBTs.

3.1 Specific Trade Concerns Database

Identifying which of the vast number of technical regulations act as trade barriers is inherently difficult. Regulations vary widely, cover different product aspects, and some may even facilitate trade (e.g., harmonization standards (Schmidt and Steingress, 2022)). To focus on potentially restrictive TBTs, I utilize the WTO database on Specific Trade Concerns (STCs) raised between 1995-2011.[9] This database documents 318 STCs concerning 403 distinct TBTs, providing details on the implementing country, affected products (usually HS codes), stated objectives, and the specific concerns raised by complaining members. Notably, STCs can be raised even for measures that were never formally notified. While the STC database provides dates of Committee meetings, it lacks the precise regulatory timelines (notification and implementation dates) needed for my analysis, a limitation often addressed in the literature by using approximations based on STC discussion periods.[10]

3.2 New Database on the Timelines of TBTs

To determine whether a TBT was implemented with prior notification, I require its official notification date and its entry-into-force date. As this information is missing from the standard STC dataset and often absent or inconsistent in general NTM databases,[11] I constructed a new database specifically for this purpose. I parsed official

[9] Available at https://www.wto.org/english/res_e/publications_e/wtr12_dataset_e.htm.
[10] For instance, defining a treatment window around the STC raising/resolution dates.
[11] Many NTM databases provide snapshots of regulations at a point in time or lack unique regulation identifiers needed for timeline tracking.

documents from the WTO's TBT Information Management System repository. Using the "Document Symbol" identifier provided for many STCs,[12] I retrieved associated documentation, primarily: i) the documents provided by the country introducing the TBT, including possibly the Notification and ii) the content of the STC from the records of the Meetings of the TBT Committee, also referred to as Minutes.

I access the first source by using an identification code provided in the STC database and download the available documentation through web scraping the WTO online repository on TBTs.[13] There are two main types of documents: the Notification and the Revision.[14] From the Notification, I extract the date of notification and the proposed date of entry into force.[15] From the Revision, I gather information on whether a "To Be Decided" date has been added later or if the initial proposed date have been modified. Unfortunately, as these documents are not standardized, the information has to be collected manually. I then text parse the information from the Minutes, which are the documents recorded by the Secretariat during the meetings, to see if there are any additional dates provided by the concerned country. The Minutes are particularly useful in cases where the country has not notified the measure or has subsequently updated it.

This procedure allowed me to identify timelines for 301 of the 403 TBTs (75% coverage).[16] I mitigate concerns about selection bias (i.e., failing to find timelines for the least transparent measures) by using multiple sources, particularly the Minutes drafted by the WTO Secretariat. Indeed, the recovery rate is comparable for notified TBTs (77%)

[12] Typically in the format G/TBT/N/[CountryISO]/[Number]. The TBT IMS is accessible at http://tbtims.wto.org/en/Notifications/Search.

[13] The identifier is called "Document Symbol". In most of the cases, it has a standard format, which includes "G/TBT/N/" followed by the country isocode at 3 digit plus the number of the notification. For example, Turkey reported a notification on December 11, 2018, under "Document Symbol" "G/TBT/N/TUR/142". The WTO Trade-Information Management System is available at "http://tbtims.wto.org/en/Notifications/Search".

[14] Potentially, there is also the Addendum and the Corrigendum, but these two sources of information are less relevant for this work, since they provide information such as the availability of translated documents or the correction of typos.

[15] An example of this document is illustrated in Figure 5 in online Appendix B.2, which demonstrates that its format is standardized, making it easy to read automatically.

[16] See Figure 6 in Appendix B.3 for a breakdown of timeline data sources.

and those never notified (67%).

3.3 Stylized Facts about TBTs

A significant portion, 45%, of the analyzed TBTs with known implementation timelines were introduced without prior notification. As shown in Table **??**, TBTs impacted various sectors, with chemicals, textiles, food-related products, and machinery experiencing the highest frequency. The sectoral distribution of unannounced TBTs mirrors that of all TBTs, indicating that surprise implementations are not targeted at specific industries. This pattern suggests a widespread issue of non-transparency across various sectors.

The principal countries implementing new TBTs include the EU, China, Mexico, Korea, the US, and India, with China being notable for its relatively recent WTO membership and frequent introduction of such measures.[17] Mexico and India, in particular, have a higher incidence of introducing TBTs unnotified compared to those announced in advance. Analysis of domestic industrial output, presented in Table 9 (Appendix), indicates a tendency for surprise TBTs in rapidly growing export sectors, though the difference in growth rates between sectors with announced versus TBTs by surprise is generally small for most countries.

I identify two type of TBTs introduced by surprise, as depicted in Figure 2: (a) Never Notified and (b) Notified with Delay. The former category encompasses measures that have never been formally notified to the WTO, such as the 1997 Mexican regulation on spirit labeling, which remains undisclosed to the WTO TBT Committee.[18] The latter involves regulations enacted prior to their official notification to the WTO, typically with an average delay of three months, underscoring a procedural gap in regulatory transparency.

[17] For detailed statistics, refer to the online Appendix 9.

[18] The European Union has sought clarification on this measure through the TBT Committee, with further details available in the WTO Database on STCs, item 20.

Figure 2: Types of TBTs introduced by surprise

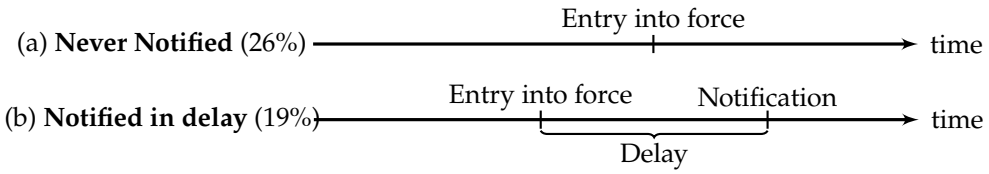


Table 1: Product Coverage of TBTs by Notification Status

Sector	# TBT	% Notified
Chemicals	381	50
Textiles	329	51
Vegetables	231	53
Machinery/Electrical	176	55
Foodstuffs	167	53
Animal Products	119	57
Miscellaneous	101	65
Metals	73	64
Transportation	58	57
Raw Hides, Skins, Leathers	41	56
Stone/Glass	37	32
Footwear/Headgear	36	50
Plastic/Rubbers	34	68
Wood Products	32	78
Mineral Products	17	71

Notes: A TBT is defined by a regulatory identifier paired with an HS4 code. The "

3.4 French Firm Level Data

The firm-level data comes from two different sources: (i) the French customs, which reports exports for each firm by destination, product and month for the period between 1995 and 2007 and (ii) BRN (*Régime du bénéfice réel normal*), the French firm level administrative database which provides information on firms' balance-sheets, over the same period.[19] The link to BRN, while it reduces the sample to relatively larger firms, allows to identify their principal activity. In this way, only manufacturing industries are selected, which are the ones directly interested by changes in technical requirements

[19]Firms are obliged to comply with BRN status if they earn annual revenues larger than 763K €. The dataset is accessed through facilities provided by the INSEE (the French Statistical Institute) and were made available for analysis after careful screening to avoid disclosure of individual information.

of production. Note that this dataset has been used in several trade related papers dealing with French data, such as Eaton et al. (2011) and Mayer et al. (2014).

I aggregate the monthly trade data at the semester level so that the final panel includes 26 periods.[20] The choice of using a semestral panel comes from a trade off between the possibility to look at the specific dates (months) in which measures are enforced and the fact that there is both seasonality and lumpiness in the export behavior. For example, the median exporter ships a certain HS4 product in a destination twice a semester.

3.5 Descriptive Statistics about the Estimating Sample

Given the availability of French firm exports in the period 1995-2007, I use a sample of 123 TBTs that have been object of a STC by the European Union and that have been introduced in the same period.[21] These 123 contested TBTs have been raised against a total of 31 different countries, with China being the largest contested country. Table 2 shows that there is a large variability in terms of HS4 categories covered by each TBT. The one that covers the largest number of products is the Mexican "Mandatory standard on Labelling of Industrial Products", which interests several products across a large number of different HS2 sections from textile to food.

I limit the sample of firms to those that export to destinations outside the EU-27, as the concerns raised by the EU are directed towards non-EU countries. As for the products, since the WTO STC database typically records them at the 4-digit HS level, I group the export data at this level, which is coarser than the original 8-digit Combined

[20] Semestral data are aggregated over two distinct six-month periods within a calendar year. The first period spans from January to June, and the second from July to December.

[21] Ideally, one would want to identify those TBTs that are trade restrictive specifically to French exporters, however, European countries participate as a single entity within the TBT Committee. On the other hand, technical regulation are homogeneous across EU countries and TBT measures are applied in a non-discriminatory way to all trading partners.

Table 2: Summary statistics about the STC database

	Mean	Median	Min	Max
# TBTs by Country	4	5.2	1	27
# HS4 categories by TBT	32	3	1	314

Notes: TBT is identified by a regulation identifier ("symbol"). Country is the one that implements the TBT ("mantaining country").

Table 3: Summary statistics of the estimation sample

	SEMESTRAL AVERAGE	
	Full sample	Affected by TBT
#(HS4, country)	35964	1122
#(exporters)	17131	2580
Total Export	3.26e+10	2.44e+09

Nomenclature.[22] Last, I calculate total export flows by destination market, retaining markets with above-10 percentile exports. Destinations in the bottom 10 percentile of total French exports accounts for less than 0.001% of total Extra-EU French export value.[23] Then, this data has been joined with tariff data from TRAINS, which contains information on the effectively applied tariffs at the HS 4-digit.[24]

Table 3 presents the average numbers of exporters, product-country pairs, and export values for both the full sample and those markets affected at least once by a TBT. Notably, although these markets constitute only 3% of the destination-HS4 pairs, they account for approximately 7.5% of the total export value, underscoring their significance for French exports.

[22] The STC database contains 6% of HS2s products, 62% HS4s and the remaining 32% are HS6 goods. I keep the level of the analysis at 4-digit HS and I drop the concerns that refers to HS2 goods (Fontagné and Orefice, 2018), to avoid imputing to all HS4 subcategories, while I aggregate the HS6 at the HS4 level.

[23] A similar cleaning procedure is applied in Fontagné and Orefice (2018). Note that the number of countries in the sample is reduced, by around 10%: from 223 Non-EU countries to 201. Among excluded countries: Aruba, Samoa, Tonga, Cook Islands, etc.

[24] HS 4-digit applied tariff data is a simple average tariff within HS-4 headings of the HS-6 applied tariff level data, this aggregation is directly provided by TRAINS. Unfortunately, the database has many empty entries, in the literature there are various algorithm that have been proposed to increase the number of observations. I apply the interpolation procedure suggested in Beverelli et al. (2014)

4 Theoretical Framework

This section develops a real-options framework to highlight how timely notifications about Technical Barriers to Trade (TBTs) can reduce uncertainty, thereby encouraging export participation. The analysis builds on standard partial-equilibrium models of international trade under uncertainty (Dixit et al., 1994; Handley and Limão, 2017), but it focuses on the role of *official notifications* as a channel for reducing the variance of possible regulatory outcomes.

4.1 Exporting Under Uncertain Standards

Consider a firm in a monopolistically competitive market that can choose whether to export to a foreign country imposing an ad valorem cost $d \geq 1$. This cost reflects the restrictiveness of a TBT. The firm's operating profit in the foreign market is

$$\pi(\varphi_i, d) \;=\; a\, d^{1-\sigma}\, \varphi_i^{\sigma-1},$$

where φ_i is the firm's productivity, $\sigma > 1$ is the elasticity of substitution across varieties, and a encapsulates demand conditions in the foreign market. In order to serve that market, the firm must pay a sunk cost K_s to adapt its processes or products to the TBT requirements. Once adaptation has occurred, the firm can export and earn profits in each subsequent period with probability $\beta < 1$ of surviving.

When the TBT is fully and promptly notified (for example, meeting the WTO guideline of a 60-day notice before implementation), exporters have relatively precise knowledge of how the measure will look once enforced. By contrast, if the TBT is announced late or not at all, significant residual uncertainty remains regarding the final level of d. Even if its expected restrictiveness is unchanged, the spread of possible outcomes widens.

4.2 Two-Period Illustration

To focus on the timing of investment, consider a simplified two-period setting. At time 0, the cost parameter is d_0. A new TBT may or may not come into effect at time 1. If it does, the new standard will be either less restrictive (d_2) or more restrictive (d_1). Timely notification ensures that firms know *precisely* which scenario will occur, whereas poor notification leaves them with only rough guesses. This can be represented by a mean-preserving spread in outcomes around d_0:

$$d_1 \;=\; d_0\,(1+\delta), \quad d_2 \;=\; d_0\,(1-\delta),$$

where the parameter δ measures the degree of uncertainty. A larger δ implies a greater variance of possible d without changing its mean, capturing the idea that lack of notification leaves exporters "in the dark" about how restrictive the TBT may ultimately be.

A firm deciding whether to adapt in period 0 compares two payoffs. The first is the expected present value from investing immediately, paying K_s now, and earning operating profits under d_0 in period 0 and under either d_1 or d_2 in period 1 (should it survive). The second is the value of waiting until period 1 to learn which TBT will materialize, then deciding whether to pay K_s. In a real-options framework, the option to wait can be valuable if the range of outcomes is large. By contrast, if δ is small—because authorities issued clear, timely notification of the new TBT—there is less benefit to waiting.

4.3 Key Equations and the Role of Notifications

Let $\mathbb{E}_0\,\Pi_0(\varphi_i, d)$ denote the expected net present value if the firm invests in period 0, and let $\mathbb{E}_0\,\Pi_1(\varphi_i, d)$ be the expected period-1 net payoff (discounted back to period 0)

if the firm waits. The firm's overall value of having the *option* to choose between these two strategies is

$$F_0(\varphi_i) \;=\; \max\Big\{\mathbb{E}_0\,\Pi_0(\varphi_i, d),\; \beta\;\mathbb{E}_0\,\Pi_1(\varphi_i, d)\Big\},$$

where $\beta < 1$ is the survival and discount factor. The difference $F_0 - \Omega_0$, with $\Omega_0 = \max\{\mathbb{E}_0\,\Pi_0(\varphi_i, d),\, 0\}$, represents the real-option value of waiting. Higher uncertainty (larger δ) increases $F_0 - \Omega_0$, implying that more firms prefer to delay.

A straightforward way to see this in practice is through the cutoff productivity φ_i^* above which a firm will invest in period 0 despite potential changes in d. When δ rises, the threshold φ_i^* shifts upward, meaning only the more productive exporters find it profitable to pay K_s right away. Timely notification effectively lowers δ; hence, it reduces the option value of waiting and encourages earlier entry or adaptation.

The exact derivation of φ_i^* follows standard steps in real-options problems with two possible future states. For completeness, I provide these steps in Appendix **??**. The key insight is that the threshold depends positively on δ, so improvements in transparency (i.e., clearer notifications) reduce that threshold and lead to wider export participation at time 0.

4.4 Implications

In this theoretical framework, the value of notifications arises precisely because it narrows the set of plausible outcomes for d. A narrower spread reduces the real-option incentive to wait, thereby encouraging firms—particularly those with moderate productivity—to commit to the export market earlier. In other words, timely notification lowers the "fog of war" around the TBT and can boost export participation relative to unannounced or belated measures.

5 Research Design

This section outlines the methodology for estimating the impact of lack of transparency associated with TBTs on firm export activities. Initially, it defines relevant variables, subsequently it details the empirical strategy, and finally it discusses the validation of this approach.

5.1 Definition of Variables

The date when TBT regulations come into effect is denoted by E_{pd}, where pd represents the combination of a 4-digit HS product category and the destination country. This date encompasses the day, month, and semester. The introduction period, denoted by I_{pd}, refers instead specifically to the semester during which the TBT enforcement begins. To identify the impact of TBTs, I employ a binary treatment variable that takes the value of one from the semester of TBT introduction in the (pd) market onwards

$$\text{TBT}_{pdt} = \mathbb{1}\{\text{t} \geq I_{pd}\}. \tag{1}$$

In those markets where a restrictive TBT has never been introduced, E_{pd} is unavailable, and thus the TBT indicator remains zero throughout. The notification date, N_{pd}, is used to define the surprise effect as:

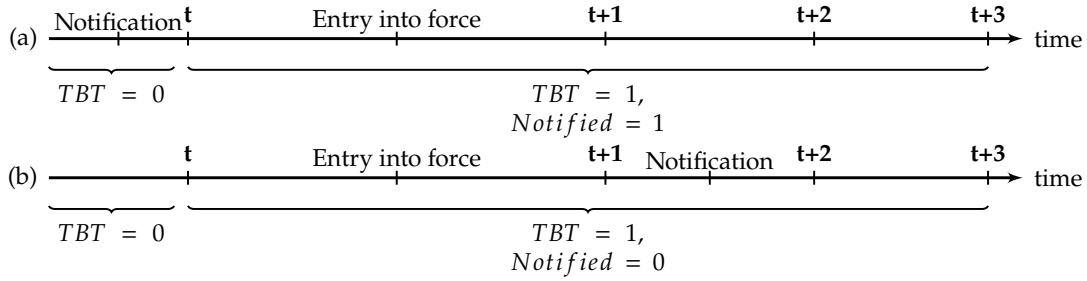
$$\text{Notified}_{pd} = \mathbb{1}\{N_{pd} \neq \text{NA and } N_{pd} \leq E_{pd}\}. \tag{2}$$

Surprise_{pd} is 1 if the regulation on product p enacted by country d has not been announced by its enforcement time. This includes unnotified regulations and those where notification occurs post-enforcement.

Figure 3 shows the behavior of these indicators across timelines for a given country-product pair, omitting the (pd) index for simplicity. In both scenarios, the TBT is

enforced in semester t, activating the TBT indicator. In Panel (a), where notification precedes enforcement, the Surprise indicator is zero. Conversely, in Panel (b), where notification follows enforcement, the Surprise indicator is one.

Figure 3: Illustration of the indicator functions for two ideal timelines



Notes: Illustration of two ideal timelines. Each timeline is product-country specific, but the index pd is dropped.

5.2 Empirical Strategy for Estimation

To investigate the impact of TBTs Notification, I estimate the following linear regression model:

$$y_{ipdt} = \alpha \text{TBT}_{pdt} + \beta \text{TBT}_{pdt} \times \text{Notified}_{pd} + \mu_{ipd} + \mu_{HS2,dt} + \epsilon_{ipdt}, \tag{3}$$

where y_{ipdt} denotes the export margin of firm i in destination d and HS4 product p. To assess both the prevalence (extensive margin) and volume (intensive margin) of trade, I employ two different dependent variables. First, a dummy variable capturing whether a firm exports a specific product to a particular destination (1 for any positive trade flow). To account for periods with no trade flows, I square the data over the "potentially active" firms in a market: those that exports to a product-destination combination in at least four out of the 26 observed periods.[25] Second, the natural logarithm of export value, in order to delve into variations in export volume beyond simple participation.

The coefficients of interest are α and β, the first captures the average effect of TBTs on

[25] This choice mirrors Fontagné and Orefice (2018), where participation in a product-destination market is determined for firms that have exported a certain product to a destination in at least 2 of the 13 years studied.

firms' product trade margins, while the second captures the additional effect associated when TBTs are introduced by surprise. I interpret the latter as the effect of lack of transparency associated to TBTs.

I include a set of HS2-destination country-period ($\mu_{HS2,dt}$) fixed effects to control for market conditions, such as the expenditure level as well as the price index in the destination market, which affects the operating profits of a firm. I also include firm-product-destination dummies (μ_{ipd}) to control for time-invariant characteristics that affect firms' product performances in the market. These include factors like firm productivity, product quality, and the significance of a product within a firm's export portfolio.

Equation 3 describes a fully saturated differences-in-differences model. It involves comparing firms' product export margins in a destination market before and after the introduction of a TBT while controlling for industry-market-specific trends.

5.3 Validation of the Empirical Strategy

In assessing trade policy impacts, it is essential to consider reverse causality, where policies respond to prior economic conditions, leading to biased estimates of trade policy effects on trade flows. Policies enacted after changes in trade patterns can understate their impact, while those anticipating trade increases may inflate their effects (Goldberg and Pavcnik, 2016). This can limit the generalizability of the findings. In relation to the setting of this work, reverse causality can occur, for example, when a foreign government implements a TBT in reaction to a surge in imports, or when the European Union (EU) challenges a market's regulations due to a drop in market share for French companies. The latter concern is somewhat alleviated by the fact that the analysis accounts for complaints raised by the EU collectively, rather than those specific to France.

To mitigate potential biases, I leverage the parallel trends assumption conditional on narrowly defined industry-destination pairs. I assume that, absent TBTs, product margins for firms in the same narrowly defined industry (HS2 category) selling to the same country will follow similar trends over time. By focusing on these industry-country pairs, one can account for industry-specific trends and other unobserved factors that might influence trade margins. Additionally, using fixed effects at the HS2 industry level helps control for any unobserved policy measures, beyond TBTs, that might affect entire industries. These policies could include support programs for environmentally friendly or high-tech sectors, or broader trade policies designed to promote or protect specific industries.

The validity of this assumption, which requires the treatment and control groups to be comparable except for the TBT implementation, is assessed through a refined version of the baseline model (Equation 3). This enhanced model incorporates dummy variables for the period before the TBT introduction, allowing to statistically test for any pre-existing differences between the groups.

The model is specified as follows:

$$y_{ipdt} = \sum_{n=-A}^{N} \left(\alpha_n + \beta_n \text{Notified}_{pd}\right) \mathbb{1}\{\text{TBTevent}_{pdt} = n\} + \mu_{ipd} + \mu_{HS2,dt} + \epsilon_{ipdt} \quad (4)$$

where n indexes the time relative to the introduction of a TBT, with $n = 0$ indicating the event time. The periods before the introduction of a TBT are denoted by $-A \leq n < 0$, and the periods after are denoted by $0 < n \leq N$. If TBTs are randomly introduced, given market conditions and time-invariant firm-product-destination characteristics, one would expect no pre-existing trends, which would mean that β_n and α_n should be zero for $n < 0$.

6 Estimates of Firms' Export Behavior

This section discusses the estimates of how transparency through timely TBT notifications affects firms' trade margins. The latter part of the section focuses on robustness tests for the research design.

6.1 Baseline Results

Table 4 presents estimates of the baseline specifications in Equation 3 for two export margins: participation (extensive margin) and export value (intensive margin).

Columns 1 and 3 show that the introduction of a restrictive TBT decreases the probability of exporting by around 4%, with no significant effect on the intensive margin—consistent with Fontagné and Orefice (2018). This suggests that TBTs primarily raise fixed trade costs, prompting some firms to exit.[26]

The additional role of notification emerges in columns 2 and 4. When TBTs are timely notified, the negative effect on participation is mitigated by about 4 percentage points, while the intensive margin remains unaffected. This aligns with the model's prediction: transparency reduces uncertainty, lowering the option value of waiting and supporting continued market participation. As expected, the impact concentrates on the extensive margin—firms choose to stay active rather than delay or exit.

6.2 Robustness Checks

Examining Pre-Existing Trends: A critical assumption of the empirical strategy is that firms affected by TBTs with or without notification were following similar trends prior to implementation. To test this, I estimate a dynamic specification tracing export

[26] Chaney (2008) predicts that fixed trade costs mainly affect the extensive margin, with little impact on the intensive margin.

Table 4: TBTs and Surprise Effect - Baseline Model

DEPENDENT VARIABLE	Participation		Export Value	
	(1)	(2)	(3)	(4)
TBT	-0.038***	-0.074***	0.012	-0.002
	(0.008)	(0.008)	(0.035)	(0.037)
TBT × Notified		0.045**		0.018
		(0.021)		(0.096)
Observations	8180250	8180250	4492290	4492290
R2	0.247	0.247	0.748	0.748
Firm-HS4-Country FE	Yes	Yes	Yes	Yes
HS2-Country-Time FE	Yes	Yes	Yes	Yes

Notes: Participation is a dummy variable for firm-product export participation (the extensive margin of exports), meaning positive trade flows into a certain product-destination market combination. The observations in cols 1 and 2 are larger than in 3 and 4 since participation accounts for trade zeros. Significance levels: $*$ < 0.1, $**$ < 0.05, $***$ < 0.01.

behavior up to 18 months before TBT introduction—the maximum lead time observed for notified measures. Table 10 in Appendix C.2 reports that coefficients for pre-TBT periods are statistically insignificant across both notified and unnotified cases. This confirms the absence of differential pre-trends and supports a causal interpretation of the notification effects. The results suggest that firms do not adjust exports in anticipation of TBTs, reinforcing the importance of formal notification as the key informational trigger.

Control for Tariffs Another potential concern is that TBTs could be introduced alongside other trade policy instruments, particularly tariffs, which might confound the estimated effects. Prior literature suggests that countries may use TBTs as substitutes for tariff reductions (Beverelli et al., 2014; Orefice, 2017). To address this, I augment the baseline specification by controlling for applied product-level tariffs at the destination level. As shown in Table 11, the inclusion of tariff controls leaves the magnitude and significance of the notification coefficients virtually unchanged. This indicates that the mitigating role of timely notification is not driven by concurrent tariff adjustments, strengthening the case that transparency itself—rather than broader protectionist strategies—explains the observed trade responses.

PPML Estimator: Given the prevalence of zero trade flows in firm-level export data, I

re-estimate the baseline model using a Poisson Pseudo Maximum Likelihood (PPML) estimator, which accommodates heteroskedasticity and retains observations with zero exports (Silva and Tenreyro, 2006; Correia et al., 2019). Table 14 presents these estimates. The results confirm that TBTs significantly reduce export values, but importantly, timely notification offsets part of this decline, consistent with the extensive-margin findings. While PPML offers advantages in handling zeros, I acknowledge its limitations in fully addressing endogenous market participation—a key economic mechanism in this context. Nonetheless, the consistency of results across both OLS and PPML specifications reinforces the robustness of the conclusion that transparency through notification mitigates the trade-dampening effects of TBTs.

7 Investment Decisions and the Role of Notifications

This section explores how notifications influence firms' long-term investment and market participation decisions in response to TBTs. Both existing exporters and potential entrants benefit from early information, reducing uncertainty around compliance costs. I decompose responses into permanent exits, temporary exits (reflecting delayed compliance), and entry decisions to capture how notification alters behavior.

7.1 Decomposition of the Extensive Margins

The introduction of a new TBT forces firms to reassess their participation in export markets. Incumbent exporters must decide whether to invest in compliance to maintain access, exit permanently, or delay their decision in anticipation of greater regulatory clarity. To capture these differentiated responses, I distinguish between permanent exits—where firms cease serving a market entirely—and temporary exits, reflecting a strategic pause while firms evaluate compliance options during the initial enforcement period.

Potential entrants face a comparable dilemma. Confronted with new regulatory barriers, they must weigh upfront compliance costs against expected returns. In this context, regulatory uncertainty discourages immediate entry. I define entry as re-engagement after at least two periods of inactivity, allowing for the identification of delayed market participation.

Table 5 presents the estimates. TBT implementation leads to a 6% increase in exits overall. Crucially, timely notification reduces temporary exits by 6 percentage points, suggesting that advance information enables firms to commit sooner rather than adopting a wait-and-see approach. While notification has little effect on permanent exits—consistent with sunk cost considerations—it significantly encourages entry, boosting it by over 5 percentage points relative to unnotified cases.

These patterns align with the theoretical model, where transparency mitigates uncertainty-driven delays in both compliance and market entry. In contrast, absent or delayed notifications amplify hesitation, leading to deferred participation and heightened market detachment. Overall, the results underscore that timely provision of regulatory information plays a pivotal role in sustaining trade relationships and facilitating smoother adjustment to technical barriers.

7.2 Duration of the Surprise Effect

To assess how long the negative effects of surprise last on export participation, I utilize a model similar to Equation 7 and plot the estimates in Figure 4 for a time window around the introduction period of the average TBT with and without Notification.

The analysis reveals that the negative impact of surprise persists in the semester after the introduction. This reinforces the idea that when firms are hit with surprise TBTs, the lack of clear information incentivizes them to postpone compliance actions (such as adapting products or processes) until they gain a better understanding of the new

Table 5: Decomposition of Export Extensive Margins

DEPENDENT VARIABLE	Permanent Exit:		Short-term Exit:		Entry:	
	(1)	(2)	(1)	(2)	(1)	(2)
$\mathbb{1}\{\text{TBTevent} = 0\}$	0.065***	0.071***	-0.001	-0.009	-0.026***	-0.019**
	(0.019)	(0.019)	(0.014)	(0.015)	(0.008)	(0.009)
$\mathbb{1}\{\text{TBTevent} > 0\}$	0.003	0.002	0.019	0.018	-0.001	-0.004
	(0.014)	(0.015)	(0.013)	(0.015)	(0.007)	(0.008)
$\mathbb{1}\{\text{TBTevent} = 0\} \times Notified$		0.042		-0.058**		0.053***
		(0.041)		(0.023)		(0.020)
$\mathbb{1}\{\text{TBTevent} > 0\} \times Notified$		0.008		0.024		0.006
		(0.023)		(0.026)		(0.019)
Observations	4606489	4606489	3886240	3886240	4248979	4248979
R2	0.507	0.507	0.422	0.422	0.279	0.279
Firm-HS4-Country FE	Yes	Yes	Yes	Yes	Yes	Yes
HS2-Country-Time FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Permanent Exit is a binary indicator set to 1 if the firm was present at least once in the last two semesters but won't ever serve the product-destination market again. Short-term exit takes value 1 if the firm was serving the market in the current semester but won't serve the market for the next two semesters, while will serve again afterwards. The dummy entry takes value 1 if the firm was not present in the product-destination at last for the last two semesters but it operates in the current one and will in the future. Standard errors in parenthesis are clustered at (product,country,time). Significance levels: $* < 0.1$, $** < 0.05$, $*** < 0.01$.

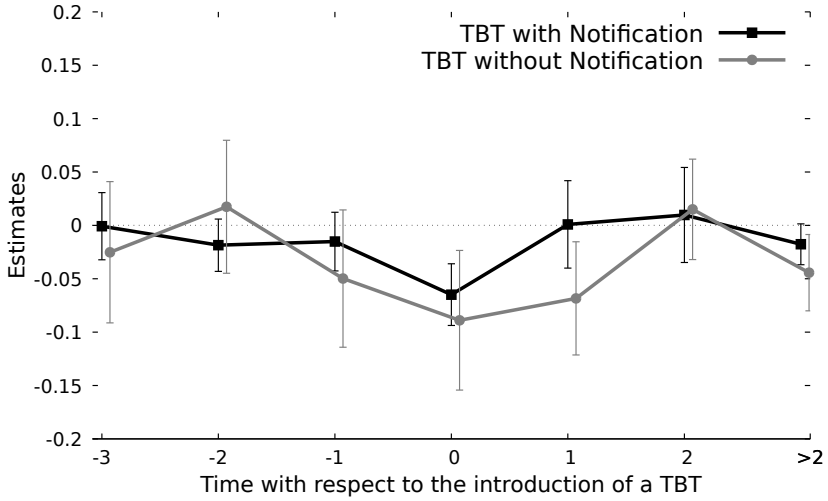
regulations. This delay in compliance likely translates to a decline in export activity in the following semester.

7.3 The Role of TBT Notifications

To evaluate how timely disclosure shapes exporters' responses, I contrast markets in which TBTs were *notified on time* with those in which regulations entered into force *without advance notice*. This comparison separates two explanations for the initial decline in exports. If the drop simply reflects the time required to meet new technical requirements, export volumes should remain subdued even after notification is eventually issued. Conversely, if the main driver is informational uncertainty, the arrival of the official notice should quickly stem the fall in exports.

I estimate a semi-dynamic specification that replaces the *Surprise* dummy with $\text{Notified}_{pd} \equiv 1 - \text{Surprise}_{pd}$:

Figure 4: Dynamic model for Participation, regression coefficients and 95% CI



Notes: The figure displays the estimated coefficients from equation 7, focusing on the periods before and after the treatment. The dependent variable is the likelihood of participation. Estimates are reported in Table 13 (Appendix). The coefficients for the first lag significantly differ at the 5% level, with an F-statistic of 4.25 and a p-value of 0.0391.

$$
\begin{aligned}
y_{ipdt} \;=\; & \mu_{ipd} + \mu_{HS2,dt} + \alpha_0\, 1\{\text{TBTevent}_{pdt} = 0\} + \alpha_n\, 1\{\text{TBTevent}_{pdt} > 2\} \\
& + \sum_{n=1}^{2} 1\{\text{TBTevent}_{pdt} = n\} \Big[\alpha_n + \beta_n^{T}\, \text{Notified}_{pd}\, 1\{\text{NotifEvent}_{pdt} < n\} \\
& \qquad + \beta_n^{U}\, (1 - \text{Notified}_{pd})\, 1\{\text{NotifEvent}_{pdt} \geq n\} \Big] + \varepsilon_{ipdt},
\end{aligned}
\tag{5}
$$

where NotifEvent_{pdt} denotes the semester in which the WTO notification is issued. Coefficients β_n^T capture the effect when the notification is received before semester n, whereas β_n^U measure the impact if notification is still missing n semesters after enforcement.

Table 6 reports the estimates. When the notification arrives in the same semester as the regulation, the initial decline in participation does not persist into the following term. By contrast, the negative effect is prolonged when notification is absent one semester after enforcement: participation continues to fall, and the difference relative to the timely-notified case is statistically significant ($F = 11.25,\ p < 0.01$). Importantly, the immediate impact at the moment of enforcement is indistinguishable between unnotified and late-notified TBTs, indicating that subsequent divergence is driven by

information rather than by differences in underlying stringency. Overall, the evidence supports the uncertainty channel: providing the notification on time encourages firms to comply and remain active, whereas continued lack of documentation prolongs the deterrent effect of technical barriers.

Table 6: Participation: Timely vs. Delayed Notification of TBTs

	Participation	
	(1)	(2)
$1\{\text{TBTevent}_{pdt} = 0\}$	-0.041^{***}	-0.046^{***}
	(0.008)	(0.009)
$1\{\text{TBTevent}_{pdt} = 1\}$	0.030	0.035
	(0.022)	(0.022)
$1\{\text{TBTevent}_{pdt} = 1\}\times(1-\text{Notified})\times1\{\text{NotifEvent}_{pdt} < 1\}$	0.049	0.048
	(0.040)	(0.041)
$1\{\text{TBTevent}_{pdt} = 1\}\times(1-\text{Notified})\times1\{\text{NotifEvent}_{pdt} > 1\}$	-0.106^{***}	-0.108^{***}
	(0.037)	(0.037)
$1\{\text{TBTevent}_{pdt} = 2\}$		0.034
		(0.023)
$1\{\text{TBTevent}_{pdt} = 2\}\times(1-\text{Notified})\times1\{\text{NotifEvent}_{pdt} < 2\}$		-0.027
		(0.036)
$1\{\text{TBTevent}_{pdt} = 2\}\times(1-\text{Notified})\times1\{\text{NotifEvent}_{pdt} > 2\}$		-0.004
		(0.039)
$1\{\text{TBTevent}_{pdt} > 1\}$	0.021	
	(0.019)	
$1\{\text{TBTevent}_{pdt} > 2\}$		0.021
		(0.015)
Observations	8180250	8180250
R2	0.248	0.248
Firm-HS4-Country FE	Yes	Yes
HS2-Country-Time FE	Yes	Yes

Notes: Participation is a dummy variable for firm-product export participation (the extensive margin of exports), meaning positive trade flows into a certain product-destination market combination. Standard errors in parenthesis are clustered at (product,country,Time). Significance levels: $* < 0.1$, $** < 0.05$, $*** < 0.01$.

8 Firm-Heterogeneous Responses

This section tests the prediction that firm efficiency governs the *benefit* it derives from receiving a TBT notification in advance. Because highly productive exporters enjoy larger margins, they have more to lose if shipments are interrupted; timely information should therefore be especially valuable to them, whereas less productive firms can afford to wait. Accordingly, market participation is expected to fall *less* for high-efficiency firms when a TBT is *notified*, with the gap widening as productivity rises.

Table 7: Heterogeneous reactions to *timely notification*

Dependent variable: Participation		
	Value added / worker	*Domestic sales*
TBT	-0.058^{***}	-0.036^{***}
	(0.011)	(0.011)
TBT × Notified	0.149^{***}	0.178^{***}
	(0.044)	(0.050)
TBT × Notified × $Prod_{t-1}$	-0.023^{***}	-0.012^{***}
	(0.007)	(0.004)
Quantification: export-participation change when Notified = 1		
average $Prod_{t-1}$	−3.5%	−1.8%
one s.d. below average	−4.3%	−4.9%
Observations	6,596,170	6,352,590
R^2	0.305	0.280
Firm–HS4–Country FE	Yes	Yes
HS2–Country–Time FE	Yes	Yes

Notes: Value added per worker and domestic sales are in logs (means 4.04 and 10.27; standard deviations 0.63 and 2.20). Standard errors clustered at the product–country–time level appear in parentheses. Significance: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

To gauge this mechanism, I augment Equation (3) with an interaction between the *Notified* dummy and a lagged measure of firm efficiency, $Prod_{t-1}$. Two alternative proxies are employed: (i) value added per worker and (ii) total domestic sales, both in logs and measured one year earlier to mitigate simultaneity bias. Table 7 reports the estimates.

With value added per worker as the proxy, a restrictive TBT that arrives with prior notification reduces the export-participation rate of the *average* firm by only 3.5%, whereas the corresponding fall would be 5.8% if notification were absent.[27] For a firm one standard deviation below the mean, the notification cushion is smaller, leaving a decline of roughly 6.7%. Domestic-sales–based results are similar: notification trims the average loss to 1.8% but barely alleviates the drop for low-sales firms. The positive coefficient on TBT × Notified × $Prod_{t-1}$ in both columns confirms that the protection afforded by timely disclosure rises with productivity.

[27] The latter figure equals the baseline TBT coefficient (−0.058) plus the interaction term when Notified = 0.

9 The Ad Valorem Value of Timely Notification

I next translate the trade-mitigating effect of *timely* notification into a uniform tariff equivalent. Following the terminology of Looi Kee et al. (2009), this amounts to computing the Market-Access Overall Trade-Restrictiveness Index (MA-OTRI) associated with the *presence* of advance notice. Formally, I seek the change in the ad-valorem rate, $\Delta\tau$, that satisfies

$$E[Y \mid \tau,\ \text{Notified} = 0] \;=\; E[Y \mid \tau + \Delta\tau,\ \text{Notified} = 1]\,,$$

where Y_{ipdt} denotes the (zero-inclusive) export value of firm i. Estimating the relationship with a PPML specification that includes both extensive and intensive margins yields

$$Y_{ipdt} = \exp\!\big[\alpha\,\text{TBT}_{pdt} + \beta\,\text{TBT}_{pdt} \times \text{Notified}_{pd} + \gamma\,\ln(1+\tau_{pdt}) + \mu_{HS2,dt} + \mu_{ipd}\big] + \varepsilon_{ipdt}.$$

Column (3) of Table 14 reports $\hat{\beta} = +0.433$ and $\hat{\gamma} = -0.107$. Because the proportional change in exports when Notified switches from 0 to 1 equals $e^{\beta} - 1 = 0.541$, the tariff adjustment that produces the same boost is

$$\Delta(1+\tau)\ \% \;=\; \frac{(e^{\beta}-1)\times 100}{\hat{\gamma}} \;=\; \frac{54.1}{-0.107} \;\approx\; -505\%.$$

In other words, receiving the notification in advance offsets a trade penalty equivalent to *adding* roughly five-hundred percentage points to the ad-valorem tariff schedule. Expressed differently, the absence of notification imposes an average MA-OTRI surcharge of +5 times the prevailing tariff level, whereas timely disclosure removes that burden.

For context, Looi Kee et al. (2009) estimate that all non-tariff barriers together raise Europe's MA-OTRI by about 307 per cent relative to tariffs alone. The single channel

of notification transparency therefore carries a trade cost—or, when respected, a trade saving—larger than that aggregate benchmark.

To gauge the magnitude at typical tariff levels, consider the sample mean tariff of $\tau^M = 13\%$ in markets affected by TBTs. Avoiding the notification lapse is then equivalent to *reducing* the tariff by approximately $0.505 \times (1 + \tau^M) \simeq 40$ percentage points, closely matching the 40% duty often used in calibrated trade-war scenarios (e.g. Costinot and Rodríguez-Clare, 2014) and identical to the surcharge China imposed on US vehicle imports in mid-2018.

Table 8: PPML with HDFE

Dependent variable:	Exports ≥ 0 (PPML)		
	(1)	(2)	(3)
TBT	−0.376***	−0.326***	−0.320***
	(0.076)	(0.077)	(0.077)
TBT × Notified		+0.450**	+0.433*
		(0.223)	(0.239)
ln(1 + tariff)			−0.107*
			(0.058)
Observations	8,082,903	8,082,903	7,550,366
HS2–Country–Time FE	Yes	Yes	Yes
Firm–HS4–Country FE	Yes	Yes	Yes

Estimates obtained with the PPML-HDFE routine of Correia et al. (2019). Standard errors (in parentheses) are clustered by HS4 ×country ×semester. Column (3) loses observations owing to missing tariff data. Significance: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

10 Conclusion

This paper demonstrates the critical role of timely notification in shaping the trade effects of technical barriers to trade. Exploiting matched data on WTO notifications and French firm–product exports, I show that a restrictive TBT that is *not* announced

in advance triggers an additional four-percentage-point fall in export participation relative to an otherwise identical measure accompanied by formal notice. A model of trade-policy uncertainty with heterogeneous firms rationalises the finding: when documentation is unavailable at the moment of enforcement, firms face greater variance in expected adaptation costs and therefore postpone compliance or exit; advance disclosure narrows that cost distribution and supports continued market presence.

By quantifying the information channel for TBTs—an area far less studied than tariff uncertainty—this paper enriches the broader literature on trade-policy risk and complements recent evidence that transparency provisions are an essential component of modern trade agreements (Mattoo et al., 2020). The results also accord with work showing that the depth and design of agreements condition firm-level gains from integration (Fernandes et al., 2021; Neri et al., 2023).

By quantifying the information channel, this paper complements work on tariff uncertainty Handley and Limão (2017) and reveals transparency itself—not regulatory stringency—as a central margin of trade policy. The results speak to current debates on deep trade agreements: transparency disciplines deliver tangible market-access benefits and should be enforced as rigorously as tariff ceilings.

A promising avenue for future research is the political economy of notification itself. Because most contested TBTs are raised in Specific Trade Concerns yet seldom escalate to formal dispute settlement (Ghodsi and Michałek, 2016), withholding or delaying notification may offer domestic producers a temporary shield against foreign competition while limiting the risk of retaliation. Understanding when and why governments choose opacity over transparency would shed further light on the strategic use of technical regulations in the multilateral trading system.

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Online Appendices

A Theory Appendix

Proposition 1. *In time 0, the marginal firm that would be indifferent between investing in the first period and postponing the investment, is the one for which the condition* $F_0 - \Omega_0 = 0$ *writes*

$$\pi_0(\varphi_i^*, d_0) = K_s(1 - \beta\lambda) - (1 - \lambda)\frac{\beta}{1 - \beta}\pi_1(\varphi_i^*, d_1). \tag{6}$$

Proof. The marginal firm that would be indifferent between investing in the first period and postponing the investment, is the one that would invest in time 1 only if the low-restrictive standard d_2 realizes. For the marginal firm that would be indifferent to invest in time 0 or in time 1 under both standards, $\pi_0(\varphi_i', d_0) = K_s(1 - \beta)$. Note that $\pi_0(\varphi_i', d_0) > \pi_0(\varphi_i^*, d_0)$ for any $\lambda < 1$, $\beta < 1$ and $\pi_1(\varphi_i^*, d_1) < K_s(1 - \beta)$. The last condition is always verified for firms that do not comply at time 1 if d_1 realizes. This implies that $\varphi_i' > \varphi_i^*$, the marginal firm that is indifferent to invest in time 0 or in time 1 under both standards is more productive than the one that will wait and invest only if standard d_2 realizes. □

B Construction of the Database

B.1 Procedure to Search Timestamps in the Content of the Concern

The STC database collects the Minutes of the TBT Committee meeting as a text variable, which is parsed using an algorithm that searches for all possible timestamps in the text. These dates are then manually reviewed to determine the relevant ones. If no relevant dates are found, measures are classified into three categories based on the content of the Minutes: (i) 'Y' if the measure is already in force, (ii) 'NY' if the measure is still being drafted, and (iii) 'NA' if there is not enough information to distinguish between the two cases. For measures that are declared in force, the introduction date is assumed to be the semester in which the concern was raised for the first time, as it is likely that the country is complaining about the adoption of a new measure in the absence of any draft. In case of conflicting dates from the Notification, the dates from the Minutes are given priority, followed by the revision dates and the proposed dates in the Notification. The information from the Minutes is preferred because countries can modify the proposed adoption or enforcement dates without providing formal documentation.

B.2 Format of a Notification

Figure 5: Example of the format of the Notification

WORLD TRADE ORGANIZATION

G/TBT/N/ARG/101
23 May 2003
(03-2765)

Committee on Technical Barriers to Trade — Original: Spanish

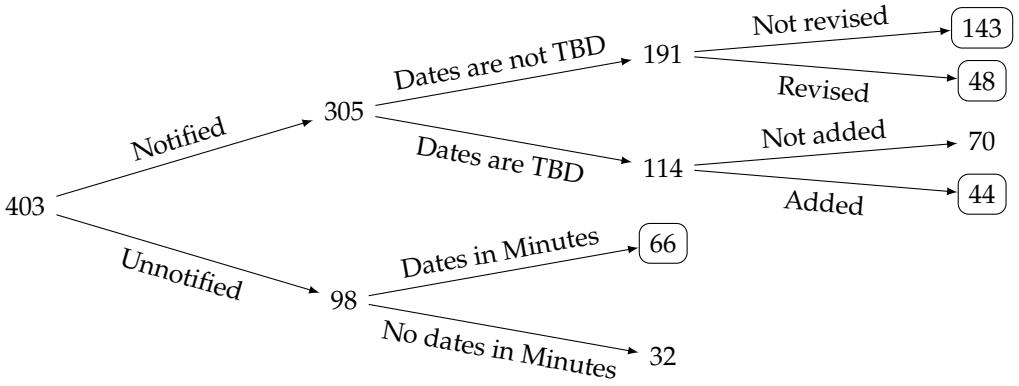
NOTIFICATION

The following notification is being circulated in accordance with Article 10.6.

1.	**Member to Agreement notifying:** ARGENTINA **If applicable, name of local government involved (Articles 3.2 and 7.2):**
2.	**Agency responsible:** National Institute of Vitiviniculture **Name and address (including telephone and fax numbers and E-mail and Web site addresses, if available) of agency or authority designated to handle comments regarding the notification shall be indicated if different from above:** *Idem* National Enquiry Point
3.	**Notified under Article 2.9.2 [** X **], 2.10.1 [ ], 5.6.2 [ ], 5.7.1 [ ], other:**
4.	**Products covered (HS or CCCN where applicable, otherwise national tariff heading. ICS numbers may be provided in addition, where applicable):** Wine
5.	**Title, number of pages and language(s) of the notified document:** Wine – Sulphate Content (2 pages, in Spanish)
6.	**Description of content:** Establishes the maximum limits for sulphate content, expressed as potassium sulphate, both in wine that is in circulation and in wineries.
7.	**Objective and rationale, including the nature of urgent problems where applicable:** The need to establish, as an exporting country, the appropriate limits for these products through essential production and conservation techniques, as laid down by the International Organization of Vine and Wine (OIV).
8.	**Relevant documents:** INV Resolution No. 14/2003
9.	**Proposed date of adoption:** 30 April 2003 (Official Journal) **Proposed date of entry into force:** 8 May 2003
10.	**Final date for comments:** -
11.	**Texts available from: National enquiry point [**X**], or address, telephone and fax numbers and E-mail and Web site addresses, if available, of other body:** Punto Focal de la República Argentina Dirección Nacional de Comercio Interior (DNCI) Avda. J. A. Roca 651, Piso 4°, Sector 22 (1322) Buenos Aires Fax: 54 11 4349 4072 Tel.: 54 11 4349 4067 E-mail: focalotc@mecon.gov.ar Web site: http://www.puntofocal.gov.ar

B.3 Data Sources for the Timelines of TBTs

Figure 6: Data sources for the database on TBT timelines



Notes: The frequency of TBTs is displayed in a tree format, organized by the source of information used to retrieve the timelines of TBTs. The edges of the tree indicate the attributes that identify the information source. Final nodes with rectangular frames indicate the cases where the timeline could be identified.

C Additional Tables

C.1 Descriptive Statistics

Table 9: Country Coverage of TBTs and Export Growth Rates

			Avg. Yearly Export Growth Rate		
Country	# TBT	% Surprise	All HS4	with TBT	with Surprise
EU	1184	50.70	2.10	2.30	2.20
CN	848	46.70	6.60	5.80	5.20
MX	489	65	2.60	1.40	1.50
KR	473	20.30	2.40	3.10	2.90
US	440	46.10	1.50	1.70	1.70
IN	432	47.20	6.20	6.40	6.60
ID	299	94.30	4.50	2.40	4.10
BR	265	64.20	3.20	5.50	5.50
TW	214	78.50			
JP	191	1.60	1.20	1.30	2.50
ZA	177	2.30	4	2.80	6.40
CA	174	1.70			
AR	172	5.20	1.90	3.10	7
EG	171	100	5.70	1.80	1.80
NZ	167	100	2.70	2.80	2.80
	130	42.30			
MY	31	41.90	3.50	3.10	
CO	28	7.10	3.50	2.70	
TR	17	100			
EC	10	60	3.60	2.90	
IL	8	100	3.10	1.60	1.60
PE	7	14.30	5.10	6.60	6.70
KE	6	100			
MD	2	100			
TH	1	100	4.40	5.20	5.20
UY	1	100	-0.40	3.50	3.50
Average	228	57.30	3.40	3.30	4

Note: A product is a HS4 code. A TBT is defined by a regulatory identifier paired with an HS4 code. The "Surprise" percentage represents the proportion of TBTs that were enforced without prior notification. Missing values are due to the fact that trade data series for those reported HS4-country pairs are not continous.

C.2 Robustness Checks

Table 10: Testing for pre-trends

DEPENDENT VARIABLE	Participation:		
	(1)	(2)	(3)
TBT	-0.031***	-0.033***	-0.033***
	(0.008)	(0.008)	(0.009)
TBT × Surprise	-0.042**	-0.043**	-0.045**
	(0.021)	(0.021)	(0.021)
$1\{\text{TBTevent}_{pdt} = -1\}$		-0.015	-0.016
		(0.014)	(0.014)
$1\{\text{TBTevent}_{pdt} = -1\} \times$ Surprise		-0.038	-0.039
		(0.034)	(0.035)
$1\{\text{TBTevent}_{pdt} = -2\}$		-0.018	-0.018
		(0.013)	(0.013)
$1\{\text{TBTevent}_{pdt} = -2\} \times$ Surprise		0.032	0.030
		(0.032)	(0.032)
$1\{\text{TBTevent}_{pdt} = -3\}$			-0.002
			(0.016)
$1\{\text{TBTevent}_{pdt} = -3\} \times$ Surprise			-0.030
			(0.036)
Observations	8180250	8180250	8180250
R2	0.247	0.247	0.247
HS2-Country-Time FE	Yes	Yes	Yes
Firm-HS4-Country FE	Yes	Yes	Yes

Notes: Participation is a dummy variable for non-zero firm-product export to a destination market. Standard errors in parenthesis are clustered at (HS4,country,time). Significance levels: $* < 0.1$, $** < 0.05$, $*** < 0.01$.

Table 11: Effects of TBTs, controlling for tariffs

DEPENDENT VARIABLE	Participation		Export	
	(1)	(2)	(3)	(4)
TBT	-0.039***	-0.031***	0.015	0.018
	(0.008)	(0.008)	(0.035)	(0.037)
TBT × Surprise		-0.042**		-0.017
		(0.021)		(0.096)
ln(1+tariff)	0.031***	0.031***	-0.047**	-0.047**
	(0.006)	(0.006)	(0.019)	(0.019)
Observations	7638178	7638178	4216252	4216252
R2	0.248	0.248	0.745	0.745
HS2-Country-Time FE	Yes	Yes	Yes	Yes
Firm-HS4-Country FE	Yes	Yes	Yes	Yes

Notes: Participation is a dummy variable for non-zero firm-product export to a destination market. Export is in log. The number of observations in columns 1 and 2 exceeds those in columns 3 and 4 because participation includes instances of zero trade. The number of observations for estimation is smaller than in the baseline because of missing tariff data. Standard errors in parenthesis are clustered by (HS4,country,time). Significance levels: $^{c} < 0.1$, $^{b} < 0.05$, $^{a} < 0.01$.

Table 12: PPML with HDFE

DEPENDENT VARIABLE	Export≥0		
	(1)	(2)	(3)
TBT	-0.376***	-0.304***	-0.328***
	(0.076)	(0.077)	(0.077)
TBT × Surprise		-0.476**	-0.433*
		(0.238)	(0.240)
ln(1+tariff)			-0.107*
			(0.058)
Observations	8082903	8082903	7550366
HS2-Country-Time FE	Yes	Yes	Yes
Firm-HS4-Country FE	Yes	Yes	Yes

Notes: Estimated using Poisson Pseudo Maximum Likelihood, using the package developed by Correia et al. (2019), which drops singletons. Standard Errors, presented in parentheses, are clustered by (HS4, country, time). The reduction in the number of observations in column 3 is attributed to missing tariff information. levels: $^{c} < 0.1$, $^{b} < 0.05$, $^{a} < 0.01$.

C.3 Persistence of the Surprise Effect

Table below reports the estimates for Figure 4. Estimates are obtained using the following specification:

$$y_{pdt} = \sum_{n=-A}^{N} \left(\alpha_n \text{OtherTBT}_{pd} + \beta_n \text{SurpriseTBT}_{pd} \right) \mathbb{1}\{\text{TBTevent}_{pdt} = n\} + \mu_{pd} + \mu_t + \epsilon_{pdt} \tag{7}$$

where variables are defined as in equation 3. The model includes $(HS4, d)$ and therefore exploits time variability within product-destination markets. The estimates plotted, and relative standard errors, are reported below.

Table 13: Coefficients plotted in Figure 4 for the dynamic specification

DEPENDENT VARIABLE	Participation:	
	Estimate	Standard Error
$1\{\text{TBTevent}_{pdt} = -3\} \times \text{OtherTBT}$	-0.001	(0.016)
$1\{\text{TBTevent}_{pdt} = -3\} \times \text{SurpriseTBT}$	-0.025	(0.034)
$1\{\text{TBTevent}_{pdt} = -2\} \times \text{OtherTBT}$	-0.019	(0.013)
$1\{\text{TBTevent}_{pdt} = -2\} \times \text{SurpriseTBT}$	0.017	(0.032)
$1\{\text{TBTevent}_{pdt} = -1\} \times \text{OtherTBT}$	-0.015	(0.014)
$1\{\text{TBTevent}_{pdt} = -1\} \times \text{SurpriseTBT}$	-0.050	(0.033)
$1\{\text{TBTevent}_{pdt} = 0\} \times \text{OtherTBT}$	-0.065***	(0.015)
$1\{\text{TBTevent}_{pdt} = 0\} \times \text{SurpriseTBT}$	-0.089***	(0.033)
$1\{\text{TBTevent}_{pdt} = 1\} \times \text{OtherTBT}$	0.001	(0.021)
$1\{\text{TBTevent}_{pdt} = 1\} \times \text{SurpriseTBT}$	-0.068**	(0.027)
$1\{\text{TBTevent}_{pdt} = 2\} \times \text{OtherTBT}$	0.010	(0.023)
$1\{\text{TBTevent}_{pdt} = 2\} \times \text{SurpriseTBT}$	0.015	(0.024)
$1\{\text{TBTevent}_{pdt} \geq 3\} \times \text{OtherTBT}$	-0.018*	(0.010)
$1\{\text{TBTevent}_{pdt} \geq 3\} \times \text{SurpriseTBT}$	-0.044**	(0.018)
N		8180250
R^2		0.771
HS2-Country-Time FE		Yes
Firm-HS4-Country FE		Yes

Notes: Participation is a dummy variable for non-zero firm-product export to a destination market. Standard errors in parenthesis are clustered by (HS4,country,time). Significance levels: $^c < 0.1$, $^b < 0.05$, $^a < 0.01$.

C.4 Quantification of the Surprise Effect

Table 14: PPML with HDFE

DEPENDENT VARIABLE	Export≥0		
	(1)	(2)	(3)
TBT	-0.376***	-0.326***	-0.320***
	(0.076)	(0.077)	(0.077)
TBT × Surprise		-0.450**	-0.433*
		(0.223)	(0.239)
ln(1+tariff)			-0.107*
			(0.058)
Observations	8082903	8082903	7550366
HS2-Country-Time FE	Yes	Yes	Yes
Firm-HS4-Country FE	Yes	Yes	Yes

Notes: Estimated using Poisson Pseudo Maximum Likelihood, using the package developed by Correia et al. (2019), which drops singletons. Standard Errors, presented in parentheses, are clustered by (HS4, country, time). The reduction in the number of observations in column 3 is attributed to missing tariff information. levels: $^c < 0.1$, $^b < 0.05$, $^a < 0.01$.