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TRADE AND THE INTENSITY OF PRODUCT REGULATION*

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Abstract

Regulatory requirements are an important determinant of production and thus trade patterns. The effects can be complex as the requirements with which firms and/or products have to comply can either hinder or stimulate international trade. We use machine learning and text-analysis tools on a core set of EU Regulations and Directives to construct a novel set of indices of EU 'regulatory intensity' at the HS 6-digit level along three dimensions: technical production requirements, compliance, and conformity assessment. We then test the responsiveness of EU imports from EU and non-EU countries to regulatory intensity by estimating a gravity model with a stringent set of fixed effects. Distinguishing between the areas of regulation is crucial to understand the its impacts on trade: higher production requirements stimulate EU imports, while higher compliance and conformity assessment requirements affect EU imports negatively, mainly from non-EU countries. The trade effects are driven by products characterised by higher complexity, and countries for which the EU is a less relevant export-destination.

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1. Introduction

Domestic product regulation is an important determinant of firms' production and trade decisions. The effect of regulation can be multifaceted and multidirectional however, as the requirements with which products need to comply to be sold on a market can either hinder or facilitate international trade. On the one hand, adherence to specific technical requirements (e.g. standards) could result in extra costs for producers and act as a non-tariff barrier to trade (Ferro et al., 2015, Fernandes et al., 2019); on the other, adapting production to more demanding criteria could help improve product quality and facilitate exporting (Chen et al., 2008; Maertens and Swinnen, 2009; Xiong and Beghin, 2014; Curzi et al., 2020; Disdier et al., 2023). This is particularly the case if different countries can agree on a common set of principles (e.g., harmonized standards, Shepherd 2007; Chen and Mattoo, 2008; Disdier et al., 2015). Furthermore, post-production, testing products to assess their conformity with technical requirements can be an additional source of costs. Finally, countries impose several types of checks on the products shipped, either at the factory or at the border, to ensure that all the procedures have been correctly followed, and that this is reflected in the use of appropriate documentation (Beestermöller et al., 2018). Due to this complexity, an assessment of the effects that regulation exerts on firms and trade necessitates detailed measures of the types of obligations that result from the underlying legislative acts.

The main contribution of this work is to construct a novel set of product-level indices at the 6-digit level of the HS classification that capture the degree of regulatory intensity arising from EU Single Market Directives and Regulations.[1] We distinguish between three areas of regulation: Technical Requirements, Conformity Assessment, and Compliance. Technical Requirements refer to the intrinsic features of the products themselves (e.g., maximum residue levels, safety standards, etc), or of their packaging and labelling; Conformity Assessment refers to the procedures needed to test products' conformity with the technical requirements; and Compliance is concerned with the checks that may be undertaken by relevant authorities.

We construct our indices using a set of rules that, we argue, are at the core of the EU Single Market. We exploit the post-Brexit Northern Ireland Protocol (henceforth, the Protocol), which lists the EU Regulations that products shipped from Great Britain must comply with to be allowed into Northern Ireland. These rules apply to products that cross the UK-EU border, and concern the key product features, processes, and procedures that the EU considers fundamental to the integrity of the EU Single Market.

[1] Henceforth we refer to all these law acts as Regulations.

We undertake close analysis of the text of the EU Regulations to identify the provisions and obligations required of economic operators. We select sets of keywords for each of the three areas of regulation, to capture the degree of regulatory intensity that characterizes each legislative act, and then use text analysis tools to retrieve the occurrence of these keywords in the EU documents. Next, we identify the products covered by each Regulation, to construct indices of regulatory intensity at the HS 6-digit level. Finally, we accurately retrieve the date of application and repeal of each Regulation, or part thereof[2], to construct indices that account for changes in regulatory intensity over time.

Our second main contribution is to test how trade flows respond to the application of the requirements included in the EU Regulations analysed. The aim is to assess the trade deterrent or trade facilitating effect that Single Market Regulations may possess. We use data on imports into each of the 28 EU countries (pre-Brexit) and exploit a gravity specification to test how EU Regulations affect imports from non-EU countries, both in absolute terms and relative to intra-EU trade. We exploit a set of high-dimensional fixed effects at the exporter-importer-HS4-year and exporter-importer-HS6 level to isolate the effect of Regulations on trade from that of other confounding factors.

We begin by testing the trade impacts of regulation using simple indices such as the number of Regulations applying to a product, the length of the Regulations (i.e., the number of words), and the total number of keywords retrieved in the text. We find that regulatory intensity has little effect on trade when using these indices, although we find a positive impact on EU import from non-EU countries relative to intra-EU trade. This finding is somewhat unexpected, and not easy to rationalize without investigating more in detail which aspects of EU Single Market rules do imports respond to, and how.

We show that exploiting heterogeneity across specific areas of regulation is crucial to capture the effects of higher regulatory intensity. On the one hand, more stringent Technical Requirements stimulate EU imports, especially those originating from high-income countries. This can be explained by the benefits accruing from producing higher quality products and signalling those features, as well as from adhering to specific standards (Disdier et al., 2023). Higher Conformity Assessment and Compliance requirements, on the other hand, reduce EU imports: Conformity Assessment appears to be a burden especially for medium- and low-income countries, while

[2] Some Regulations are only partly replaced by new Regulations, and the timing with which new Regulations repeal parts of old Regulations is not always uniform (i.e. certain articles stop applying or enter into force at a later/earlier date than other parts of the Regulation).

Compliance has a negative impact on imports from high-income countries. The effect of Compliance is about twice as large than that of Conformity Assessment: this can be explained by considering that for Conformity Assessment both positive and negative channels can be present, in terms of higher testing costs that can be partly offset by being able to exhibit a CE marking label, for instance. In comparison, for Compliance we can expect mostly negative effects arising from longer shipping times, risk of rejections at the border, or negative repercussions of other kinds of penalties applied to firms. Intra-EU trade is found to be less affected by changes in regulatory intensity than imports from non-EU members, although we find a positive effect of Technical Requirements and a negative effect for Compliance also on EU imports from intra-EU partners.

We corroborate these findings by investigating two additional hypotheses. First, we analyse the role of product complexity.[3] Higher regulatory intensity could result in costs that are proportionately larger for higher complexity products, and thereby result in larger trade deterrence/enhancing effects. The estimation results appear to confirm this intuition. We find that the trade effects of regulatory intensity are strongly driven by products in the top quartile of the complexity distribution, especially for the positive effects of Technical Requirements and the negative ones of higher Compliance. Second, we investigate if the response of trade to regulation varies with the relevance of the EU as an export destination. Insofar compliance with EU regulation is costly, trade from countries for which the EU accounts for a smaller (larger) share of their overall exports could respond more (less) strongly to changes EU Single Market rules, as these countries might find it less (more) profitable to invest to meet the new requirements. This hypothesis should apply primarily to the areas of regulation that are trade-dampening, i.e. Compliance and Conformity Assessment. We find empirical support for this hypothesis as well: EU imports are found to be more responsive to changes in Compliance and Conformity Assessment when originating in countries in the lower quartiles of the EU export-share distribution, with imports from countries in the top quartile (i.e. for which the EU is an important market) being completely unaffected. Interestingly, we find a similar pattern for the positive trade impact of Technical Requirements; i.e. imports from (high-income) countries for which the EU is a relatively less important partner are found to increase by more: we conjecture this might be explained by an attempt of such countries to take advantage of new production requirements that allow them to increase their sales in the EU.

[3] This is based on the Hidalgo and Hausmann (2009) complexity index.

This study contributes to the literature on Non-Tariff Measures (NTMs) and their impact on trade. The focus on the impact of EU Single Market Regulations situates our work in the branch of studies analysing the trade effects of *behind-the-border*, non-discriminatory, NTMs using what Chen and Novy (2012) define as the "direct approach" (i.e. we collect data on NTMs and estimate their impact on trade in a gravity model setting).[4] The papers most directly related to the current study are therefore those studying the effect of specific NTMs[5] such as Sanitary and Phytosanitary Standards (SPS) and Technical Barriers to Trade (TBT) (Bao and Qiu, 2012; Fontagné et al, 2015; Crivelli and Gröschl, 2016; Murina and Nicita 2017; Timini and Conesa, 2019; Curzi et al., 2020; Peci and Sanjuan, 2020; Fiankor et al., 2021b; Disdier et al, 2023; among others).

The literature on trade effects *behind-the-border* NTMs is extensive, and we provide a (non-exhaustive) review in the next section. Our paper, however, makes a number of distinct contributions, and differs from this literature in several key respects. First, the current study represents the first to develop an index of regulatory intensity based on a detailed textual analysis of EU Single Market Regulations and Directives. We do not focus on a specific type of NTM (e.g. SPS, TBT, or MRLs), and do not rely on a list of measures compiled and pre-classified by an external source (e.g. the UNCTAD TRAINS database). We use an extensive list of EU legislative acts, that the EU Commission selected and included in the post-Brexit Protocol on Northern Ireland as key requirements with which goods moving across the EU border (from Great Britain to Northern Ireland in that particular case) must comply. This list singles out the core principles for operating in the Single Market. Our index captures mostly what UNCTAD TRAINS defines as technical NTM (i.e. non-discriminatory behind-the-border measures). However, it is constructed on the basis of a considerably larger number of documents than those referred to in TRAINS as sources of NTMs in the EU. The TRAINS dataset contains only 503 NTMs for the entire European Union, and within the supplied text excerpts[6], only 101 distinct Directives and Regulations can be identified, as opposed to the 257 used in our method. Therefore, we capture a broader range of NTMs which can potentially affect trade.

[4] Another branch of the literature pursues a different approach and estimates the effect of NTMs indirectly through examining anomalies in prices or trade flows relative to a hypothetical (estimated) 'NTM-free' level.
[5] To estimate the *overall* impact of NTMs on trade, as opposed to the effect of a specific measure, authors have focused on calculating ad-valorem tariff (AVEs) equivalents of NTMs (i.e., the ad-valorem tariff that would produce to the same value of imports as the NTMs (e.g., Niu et al., 2018)). Recently, Ghodsi and Stehrer (2022) have extended this method to compute AVEs by type of NTMs. A comprehensive description of the landscape of NTMs and the empirical approaches that have been used to estimate their effects can be found in Ederington and Ruta (2016).
[6] TRAINS makes available text excerpts (e.g. paragraphs with keywords) from legislative documents that have been used to identify NTMs.

Importantly, to validate our approach and our choice of the key terms used to identify NTMs, we use deep-learning techniques to train a text classifier algorithm on the pre-established categorization of NTMs in TRAINS. This enabled us, through out-of-sample predictions, to assign a 'TRAINS category' to each of the documents (and paragraphs therein) containing the key terms we use in the construction of our regulatory index. There was a close mapping between the TRAINS categories and the paragraphs including the keywords we have selected, which suggests that our index validly and robustly identifies NTMs.[7]

Second, our indices allow us to capture different aspects of product regulation, and we show that making such a distinction matters to unveil its variegated effects. Furthermore, our indices capture the intensity of regulation, and go beyond a mere count of NTMs applying to a certain product, or the share of products covered by NTMs, as done by other studies thus far.

Third, some of our empirical results are also novel. We estimate the heterogeneous effect of three areas of regulation jointly in a model, and find it to be positive for technical requirements and negative for compliance and conformity assessment. While a small number of studies distinguished between Product Standards (this is closest to our Technical Requirements category) and Conformity Assessment[8], we are not aware of previous works that included also aspects of Compliance in the analysis. To the extent that our Compliance index captures (also) the trade dampening impact of border checks, however, our findings can be related to the literature on trade facilitation (Volpe Martincus, 2015; Carballo et al., 2024). Across income-per capita groups, we show that both low-income and high-income countries are affected by increasing regulatory intensity, and that the effect of different areas of regulation are more nuanced than the typical finding of lower income countries being more (negatively) affected by NTMs than higher-income countries. There are elements of novelty also in the product complexity and the export-share hypotheses. We are not aware of works exploiting explicitly the product-complexity dimension in assessing the impact of NTM. Fiankor et al. (2021b) also study the role of market shares, but they exploit the relevance of an exporter in a country's total imports, while we study the relevance of an importer out of a country's total exports: we believe that our approach in more appropriate to capture 'investment incentives' for an exporter in response to new NTMs applied by an importer.[9]

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7 More details on this validation exercise are provided in the Appendix.

8 Chen et al. (2008) and Crivelli and Groeschl (2016) distinguish between SPS and TBT measures related to product and quality standards on one side, and conformity assessment procedures on the other. Both find divergent trade effects of the two types of NTMs, positive for the former and negative for the latter.

9 A country could have a large share of another's total imports (e.g. a large fraction of Belgian imports originate in China), but the latter country might still be unimportant in the former's total exports (a small share of Chinese exports go to Belgium).

Finally, we show that increasing regulation can affect 'intra-national' trade; in our case, intra-EU trade. Aside from the studies on the harmonization of EU standards, we are not aware of research on the effect of specific areas of regulation on intra-EU trade. Domestic producers have no option but to comply with new requirements. However, firm production costs can still be affected by stricter standards or inspection procedures, which in turn might lead to less production for the internal market. We find both positive and negative effects on intra-EU trade, from Technical Requirements and Compliance, respectively.

The rest of the paper is organized as follows. In Section 2 we summarize the NTM literature most directly related to our paper. In Section 3 we present the details of the construction of the regulatory indices. Section 4 exploits our indices to provide some descriptive evidence on EU Single Market regulation. Section 5 presents our empirical approach to test the trade impact of EU regulation on EU imports. Section 6 exposes the results. Section 7 provides some concluding remarks.

2. Related literature

NTMs come in many different forms, and capture both import and export measures affecting trade. A distinction can be made between non-technical and technical measures, as found in the UNCTAD TRAINS database. The former group includes, for instance, quantitative restrictions, import licensing, subsidies, rules of origin, taxation. The latter group includes SPS, TBT, and pre-shipment inspections. Another distinction can be made between measures that discriminate between domestic and foreign goods (e.g. custom procedures), and non-discriminatory measures (e.g. *behind-the-border* measures which include domestic regulation in health and environmental issues, or other standards with which all products are required to comply regardless of their origin). Domestic regulation in foreign markets, such as SPS or TBT, are among the biggest obstacles for producers due to their diversity across markets and the large share of trade that is subject to such regulations, particularly in developed economies such as the EU. SPS measures are mostly found in agriculture, whereas TBT are more cross-cutting, with pharmaceuticals being one of the most affected industries (Ederington and Ruta, 2016).

A key issue with analysing the impact of NTMs is the imprecision with which they are reported, as the measures are often qualitative in nature, and this complicates assessing their stringency. For this reason, a variety of methods and sources have been used to retrieve information on NTMs. For both SPS and TBT a popular approach has been to rely on data on Specific Trade Concerns.

These are concerns raised in the WTO about NTMs applied by other countries, as these are measures that can be considered as substantial trade barriers (Fontagné et al, 2015; Crivelli and Gröschl, 2016; Fontagné and Orefice, 2018; Curzi et al., 2020; Fiankor et al., 2021b). Alternatively, authors have used the UNCTAD TRAINS database (Essaji 2008; Murina and Nicita 2017; Timini and Conesa, 2019; Peci and Sanjuan, 2020; Disdier et al., 2023) which collects information on different types of NTMs, or notifications of NTMs to the WTO (Fontagné et al, 2005; Bao and Qiu 2012, Curzi et al., 2020): both these databases allow the computation of simple indices of regulatory intensity such as a count of NTMs applying to a certain product, or the share of products covered by NTMs, but not enable the investigation of the degree of stringency/intensity of the NTMs. Several other studies, mainly those focusing on agricultural trade, have instead exploited explicit measures of standards such as maximum residue levels of pesticides, in absolute or relative terms (Drogué and De Maria, 2012; Xiong and Beghin, 2014; Ferro et al., 2015; Fernandes et al., 2019, Fiankor et al., 2021a). More recently, Kinzius et al., (2019) have used the extensive Global Trade Alert database, which has collected information on all unilateral policy decisions likely to affect trade since 2009.

Compliance with standards and technical regulations has typically been found to restrict trade. This is partly due to some studies focussing on those NTMs likely to results in additional production or trade-related costs (Murina and Nicita, 2017; Kinzius et al., 2019), or those perceived as trade barriers and therefore leading to a WTO concern. The negative effect of product standards is generally observed on the extensive margin of exports, but not on the intensive margin, suggesting that standards tend to increase the fixed costs of exporting (Bao and Qiu, 2012; Ferro et al., 2015; Crivelli and Gröschl, 2016; Fernandes et al., 2019: Disdier et al., 2023). The trade reducing effects of NTMs are generally found to be larger for developing countries compared to developed countries (e.g., Disdier et al., 2008; Xiong and Beghin, 2014; Ferro et al., 2015; Murina and Nicita, 2017), although Bao and Qiu (2012) find that developed countries exports are also negatively affected by TBTs imposed by other developed countries. Fiankor et al., (2021b) also show that countries trading larger trade volumes tend to be less affected by SPS measures. Across firms, small firms are more subject to harm than large firms (Fontagné et al, 2015; Fernandes et al, 2019), especially by more restrictive NTMs targeted by STCs at the WTO (Curzi et al., 2020).

Positive trade effects are found more rarely, and generally at the intensive margin (Bao and Qiu, 2012; Crivelli and Gröschl, 2016), conditional on export entry. Curzi et al., (2020) find positive effects both at the extensive and intensive margin for Peruvian firms, although this arises from a subset of less restrictive SPS and TBT measures.[10] Recently, Disdier et al. (2023) find that SPS and TBT measure raise the export probability of high quality-high productivity firms, as well as their sales, at the expense of low-quality-low-productivity firms. Also product-quality is enhanced, provided exporters are productive enough.

There is a smaller body of work that is closely related to this paper as they attempt to disentangle the effect of product standards from that of certification procedures. Chen et al. (2008) use a cross-sectional survey and find that compliance with quality standards and labelling requirements are positively related to both firms' export volume and scope (number of products and destinations served), while certification procedures lead to a decline in product scope. Similarly, Crivelli and Gröschl (2016) find that SPS measures related to conformity assessment are a market entry barrier, whereas measures related to product characteristics can lead to more trade, conditional on entry.

Curiously, despite all the discussion of the benefits of the EU Single Market, there has been little attempt to our knowledge to quantify those possible benefits through analysing the Regulations underpinning the Single Market, with the exception of some sectoral studies. Shepherd (2007) and Czubala et al (2009) study the effect of EU standards[11] on imports of textiles and clothing, with the latter study providing a focus on imports from African countries. Both find a negative impact of standards on the extensive margin, although EU standards that are harmonized to ISO standards are less trade restrictive. Murina and Nicita (2017) analyse the trade effect of selected EU SPS measures on agricultural imports, and find trade dampening effects on exports from developing countries, partly mitigated by the presence of a trade agreement with the EU. Curzi et al. (2018) find that EU Maximum Residue Limits (MRL) reduce imports from developing countries in particular, while they facilitate EU exports to non-EU countries.

3. Index of regulatory intensity

The starting point for the index of regulatory intensity for the EU Single Market consists of identifying a list of suitable Regulations.

In the Brexit Withdrawal Agreement, the EU and the UK agreed on including a Protocol delineating the trade regime applicable to goods shipped from Great Britain (GB) to Northern

[10] Bao and Qiu (2012), Crivelli and Gröschl (2016) find positive intensive margins effects of TBT and SPS, respectively. In contrast, Fontagné et al., (2015), using firm level data, detect negative intensive margin effects for French firms as a consequence of SPS concerns.

[11] These papers focus on voluntary standards issued by the European Committee for Standardization (CEN).

Ireland (NI). The Northern Ireland Protocol (NIP) was made necessary to reconcile the problem of the UK exiting the EU Single Market and the Custom Union without introducing a hard border between Northern Ireland (part of the UK) and the Republic of Ireland (part of the EU).[12] The Protocol effectively placed the border between the EU and the UK in the Irish Sea. This is a customs and regulatory border, and products moving from GB to NI must be shown to comply with the EU Single Market rules contained in approximately 300 Regulations and Directives listed in Annex 2 of the Protocol. The NIP has since been amended and upgraded by the Windsor Framework (adopted on the 24th March 2023) which allowed for a 'red' and 'green' lane for goods being sold from the GB to NI, with the former designated for those goods at risk of being sold in the EU through Northern Ireland (i.e., in the Republic of Ireland). However, the Windsor Framework retains the same regulatory principles for all goods 'at risk' of going to the EU (i.e., the red lane goods). For the purposes of this work, however, regardless of the evolution of the situation on the ground, and of the regime applicable to GB-NI trade, what matters is that in the NIP the EU Commission singled out a core list of principles and procedures that it considers key for the operation of the Single Market.

We identified 257 Regulations from the Annex, discarding Regulations that either do not impose obligations on firms (e.g., that impose obligations on the EU Commission, or on Member States, or on other individuals), or are cross-cutting and therefore do not allow the products to which they refer to be identified. Examples of the latter are Council Directive 85/374 EEC on the liability for defective products, or Directive 98/34 EC on a procedure for the provision of information in the field of technical standards and regulations.

As a next step we examined the 257 Regulations to identify the requirements and obligations they impose on economic operators. To systematize this operation and extract the most relevant information we identified the keywords which capture these requirements and obligations. These needed to be specific enough to describe operations that could result in extra costs or procedures for firms, but general enough for them to be applicable across a broad range of products. Due to the different types of obligations occurring at various stages between production and sale (e.g., the production process, placing of goods on the market, border checks) the keywords were grouped into three main categories: Technical Requirements, Conformity Assessment, and Compliance. For example, for Technical Requirements, examples of keywords are "technical documentation", "production procedure", "residues", "essential requirement", but also words related to the

[12] The latter was considered a necessary safeguard for the peace process in Ireland as established under the 1998 Good Friday Agreement.

packaging and labelling of products. For the conformity assessment of products to the requirements, relevant words include "conformity assessment procedure", "certificate of conformity", "declaration of conformity", "EU type. Finally, the category of terms describing compliance processes includes words such as "verify", "inspection", "authorization", "monitoring", "traceability", "surveillance". The full lists of keywords for the three categories are provided in Table 1.

Table 1: Regulatory indices keywords

Technical Requirements	Conformity Assessment	Compliance
Harmonised standards	Conformity assessment	Border/Customs control
Harmonise	Conformity assessment procedure	Checks
Standards	Declaration of conformity	Inspection
Marketing	Certificate of conformity	Sampling
Quality standards	CE marking	Verify
Technical documentation	Conformity marking	Verification
Production procedure	Internal production control	Authorize
Essential requirement	Module A	Authorisation
Specifications	Notified body	Approval procedure
Residue	Conformity assessment bodies	Authority
Maximum	EU type	Compliance
Minimum	EC type	Monitoring
Weight	Type approved	Surveillance
Codex Alimentarius	Module B	Traceability
Label	Module C	License
Labelling	Module C1	Penalties
Package	Module D	
Packaging	Module D1	
Hazard	Module E	
	Module F	
	Module F1	
	Module G	
	Module H	

Source: in the table we separate the keywords by groups that can be considered as synonyms of each other. authors' elaboration

Next, we employed a wide array of text analysis tools to automate the keyword search across the EU Regulations. This step entailed downloading the documents corresponding to each legislative act, followed by cleaning and processing the text using text mining and natural language processing (NLP) techniques. The first part of the processing involved eliminating elements such as punctuation, numbers, and symbols that did not carry any semantic meaning. We then tagged each word with its part-of-speech details, and classified them as verbs, nouns, adjectives, among other types.

The next stage involved lemmatising the entire body of text. Lemmatisation is a process of linguistic normalisation, where words are reduced to their base or dictionary form, known as a lemma. For example, plural nouns like "children" and "cats" become "child" and "cat". Similarly, different forms of the verb "run", such as "running", "runs", and "ran", are all reduced to their base form, "run". This process is crucial for our purpose as it ensures consistency and reduces the dimensionality of the documents. Beyond its function of linguistic normalisation, lemmatisation also provides a powerful tool for distinguishing different uses of a word based on its contextual meaning. One illustrative example is the word "labelling". This term can serve as a noun, representing the process or activity of assigning labels. Conversely, "labelling" can also act as a verb, describing the action of assigning labels to something. The context in which "labelling" is used allows lemmatisation to correctly identify it as either a noun or a verb, thus significantly improving the precision of our text analysis. Once the text was cleaned, tagged, and lemmatised, we conducted the keyword search on this processed text.

For each of the three categories of Technical Requirements, Conformity Assessment, and Compliance, we computed three types of indices, specific to each Regulation:

- Index **Count-Syn**: This counts the unique number of non-synonym keywords that appear in a Regulation for a certain category. In order not to double count words that can be considered synonyms of each other, we grouped the keywords for each category in sets of potential synonyms.[13] The Index Count was then computed by counting the number of synonym groups (or non-synonym keywords). This is our preferred version of the index, and the synonym groups are shown in Table 1.

[13] The grouping of words into synonyms contains some elements of discretion and personal judgment. In contentious cases where, for example, the words comply/compliance should be considered synonyms of authority/authorization, we inspected how they keywords are used across the regulations. For instance, we computed correlations between the number of times the keywords appear across regulations. For the case of compliance and authority, the correlation is over 80% (hence the words are used jointly in the text in a large majority of cases), and we therefore decided to consider them as synonyms. For robustness, however, we have estimated all models presented in this paper both with all three types of indices, i.e. the Count-Syn., the Count, and the Sum. Results obtained with the first two versions, the Count-Syn and the Count, are remarkably similar, suggesting that the grouping of keywords into synonyms makes barely any difference to the results. Results with the Index Sum show a similar sign pattern, although coefficients are less statistically significant.

- Index **Count**: this counts the unique number of keywords, but without using the grouping into synonym groups. We use this Index as a robustness check, to verify that the choices we made to assign words to the synonym groups do not distort or drive the results.
- Index **Sum**: This counts the number of times each keyword appears on the document, summing across the keywords in a certain category. For this index we count each occasion a keyword appears in the text. This is our least preferred version of the index, as the repetition of each keywords in the text might not necessarily imply extra regulatory restrictiveness, but simply inflate the value of the indices. Nonetheless we use also this index in our robustness exercises.

Besides the indices just described, which are based on the content of the Regulations, we have also computed simpler indices based on the structure of the documents. This includes the total number of Regulations applying to a product, and the total number of words in those Regulations. The rationale behind the construction of this second set of indices is that more Regulations, or longer texts, could indicate a larger number or more complex requirements for economic actors. It is worth noting that the EU Regulations and Directives differ substantially in length with some being only a few pages long with others running to over a thousand pages.

An important aspect of the construction of the Indices has been ensuring that we capture correctly the variation in regulatory intensity over time. We do this by identifying the dates of entry into force and disapplication (or repeal) of each Regulation. This step does not simply involve collecting entry into force and repeal dates. This is because several Regulations, or more accurately elements of those regulations (61 out the 257), have been applied and disapplied in different parts at different points in time. For example, certain articles have been applied from a certain date, and some other articles from a later date. Similarly, certain articles have been replaced by new Regulations earlier than others. In order to remove the issue of either double-counting regulatory requirements arising from partly disapplied Regulations (in case the full Regulation was used in the construction of the index up to the date when all articles have been disapplied), or missing to consider requirements arising from a late disapplication of certain articles (in case a Regulation was not used in the index from the date the first articles have been disapplied), we split such Regulations into Pseudo-Regulations. Each Pseudo-Regulation is characterized by uniform dates of entry into force and disapplication of all the articles. This has led to a final number of 330 Pseudo Regulations. In Table

2 below, however, we present the key descriptive statistics at the level of the main 257 Regulations on which our indices are based.[14]

In order to construct product-level indices, we then matched each Regulation (or Pseudo Regulation) to the products covered at the HS 6-digit level. This required an extensive manual search of the HS codes to which each Regulation refers. For some Regulations the HS codes are directly listed in the text but, in many cases, the Regulation needed to be to read and interpreted in order to identify the products, or product-groups (e.g., entire H2 or HS-4-digit category) covered by the Regulation. Overall, there is a match of 5,077 out of 5,388 products in the 2017 HS 6-digit classification.

Finally, note that more than one Regulation applies to most products. For instance, the average number of Regulations applying to a product is 7.6 (bottom row of Table 2). So, to construct 6-digit product-level indices, which is the dimension at which the analysis is conducted in this paper, we summed the value of the Regulation (or Pseudo-Regulation-) indices over all the Regulations that apply to a certain product.

The key characteristics of the Indices are summarized in Table 2. On the one hand, the Regulation-level indices reveal that the documents we use are very heterogenous in terms of length and words, and products covered. On the other hand, the indices based on the content of the documents assume similar average values, especially for the Count-Syn. indices, as these are based on a reduced number of grouped keywords. The product-level indices present similar features to the Regulation-level ones. Most products see few Regulations applying to them, with few products to which a large number of Regulations apply.[15] More descriptive features of the indices are presented in the next section.

[14] This implied summing the value of the indices over the Pseudo Regulations originating from a certain Regulation. We opted to present the descriptive statistics in Table 2 in this form, as Table 2 offers a static snapshot of the main features of the Regulations used in this paper. The use of Pseudo Regulations, on the other hand, is crucial when constructing the time varying versions of our indices as used in the figures contained in Section 4 below.

[15] Note that the descriptive statistics in Table 2 do not reflect the time variation in the data. To construct the product-level indices, therefore, we summed the regulatory intensity of the various regulations applying to each product, regardless on when they entered into force. In the empirical estimation, we will use time-varying product level indices, summing the regulatory intensity of the regulations applying to a certain product in each year.

Table 2: Regulatory indices – key descriptive statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
			Regulation level		
No. Products	257	150.28	267.49	1	1013
No. Words	257	9614.58	15166.29	408	144875
Indices Count – Syn.[16]					
Tech. Requirements	257	3.73	2.06	0	10
Conformity	257	1.00	2.02	0	9
Compliance	257	3.52	2.00	0	11
Indices Count					
Tech. Requirements	257	6.29	4.15	0	24
Conformity	257	2.02	4.61	0	22
Compliance	257	7.77	5.21	0	32
Indices Sum					
Tech. Requirements	257	45.54	63.57	0	564
Conformity	257	41.34	123.63	0	893
Compliance	257	108.50	210.84	0	2006
			Product level		
No. Regulations	5,077	7.61	8.65	1	37
No. Words	5,077	123535.7	152875.6	1042	600035
Indices Count – Syn.					
Tech. Requirements	5,077	33.20	33.24	0	143
Conformity	5,077	7.03	9.86	0	55
Compliance	5,077	29.29	29.03	1	125
Indices Count					
Tech. Requirements	5,077	58.25	58.39	0	249
Conformity	5,077	12.23	19.40	0	113
Compliance	5,077	66.95	69.92	1	306
Indices Sum					
Tech. Requirements	5,077	522.89	577.00	0	2340
Conformity	5,077	205.93	358.02	0	2822
Compliance	5,077	1371.02	1831.84	1	6661

Source: authors' elaboration

4. Descriptive evidence

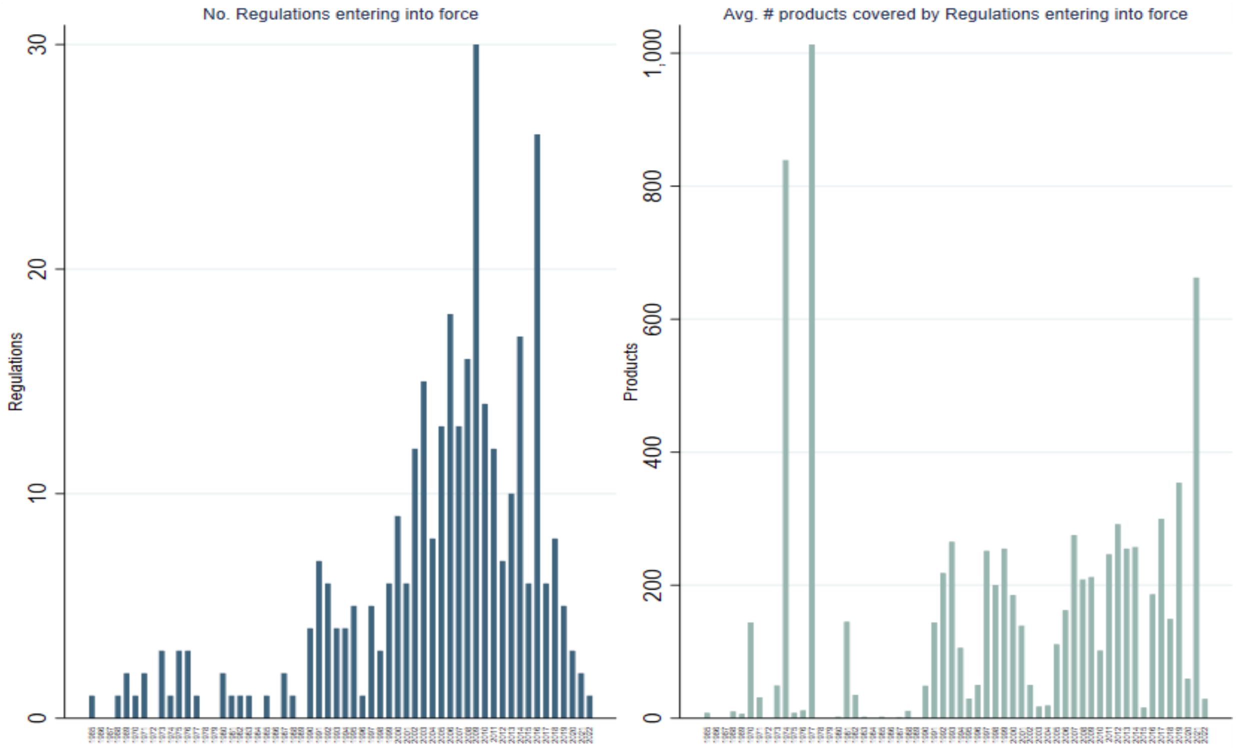
This section presents some key descriptive features of the indices of regulatory intensity. The figures are based on the 330 Pseudo-Regulations, as discussed in Section 3 above. For simplicity, we refer to the Pseudo-Regulations as Regulations.

We initially consider the variation over time in these indices. The left panel of Figure 1 shows the number of Regulations entering into force in each year and this exhibits a good deal of variation

[16] The maximum value for the Index Count-Syn. is higher than the groups of synonyms (i.e., 5 each of the three areas), as the index is computed at the level of 330 Pseudo-Regulation, while for Table 2 we have presented key statistics at the level of the 257 original Regulations (i.e. summing the value of the indices over the Pseudo-Regulations in which a certain Regulation was split).

over the decades, with a number of old Regulations from the late 1960s in the sample. However, the bulk of the Regulations entered into force from 2000 onwards.

Figure 1: number of regulations over time and products covered.



Source: authors' elaboration

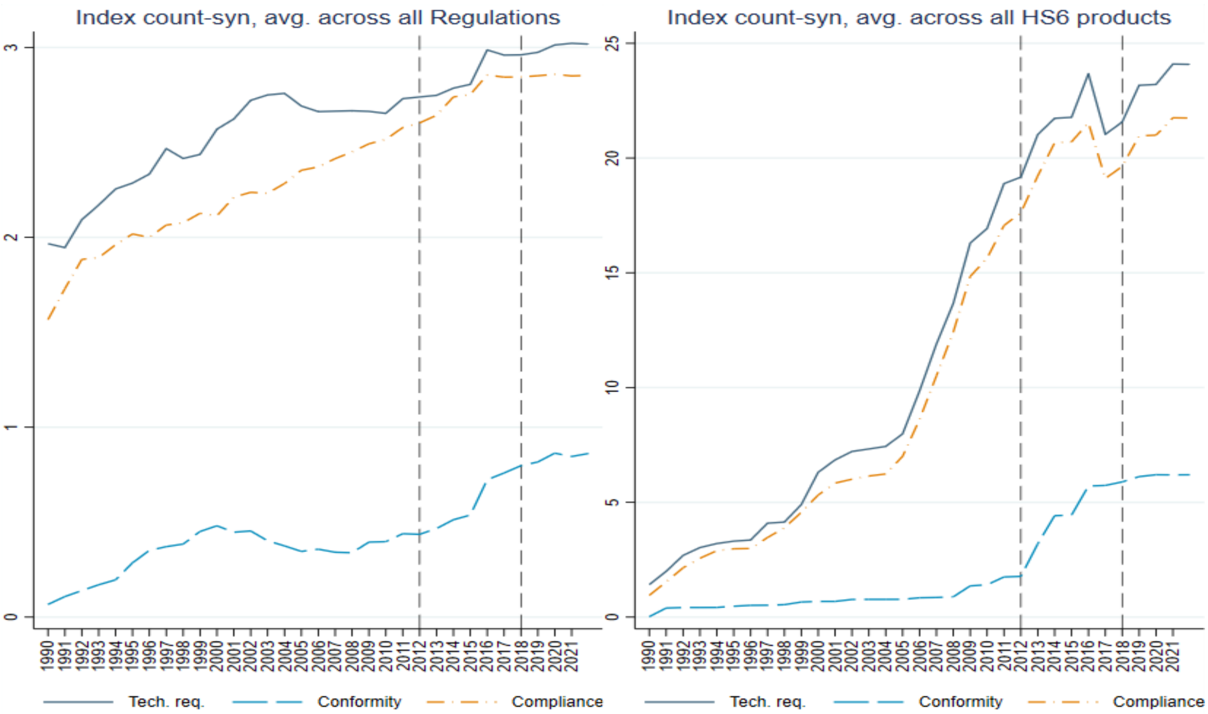
The right panel of Figure 1 is constructed using the matched Regulation-products data, and depicts the average "depth" of the Regulations entering into force, as characterized by the number of products covered. Note how the number of products covered varies more widely over the initial years of the data, with very few relatively over-arching regulations entering into force. However, a significant degree of variation characterises the last two decades, perhaps driven by the larger number of regulations entering into force over this period.

Figure 2 shows the mean yearly values assumed by the Index Count-Syn. since 1990. The left panel reports the value of the index in the three categories of Technical Requirements, Conformity Assessment, and Compliance on average across all Regulations, while the right panel plots the average of the product-level indices.

On aggregate, the three categories of the indices follow a similar upwards trajectory, with Technical Requirements and Compliance also being of a similar magnitude, while the mean value of the index for Conformity is substantially lower. This is found for both the mean values computed across

Regulations, and across products, and is it mostly due to issues concerning Conformity arising in fewer regulations than issues concerning Compliance or Technical Requirements.[17]

Figure 2: Index Count-Syn. over time



Source: authors' elaboration

In Figure 2 we also depict the changes in regulatory intensity over the 2012-2018 period, which we will use in the econometric analysis, where marked changes over time are observed.[18] Lastly, in Figures 3 we provide a detailed snapshot of the heterogeneity of the regulatory indices across 2-digit chapters of the HS classification.[19]

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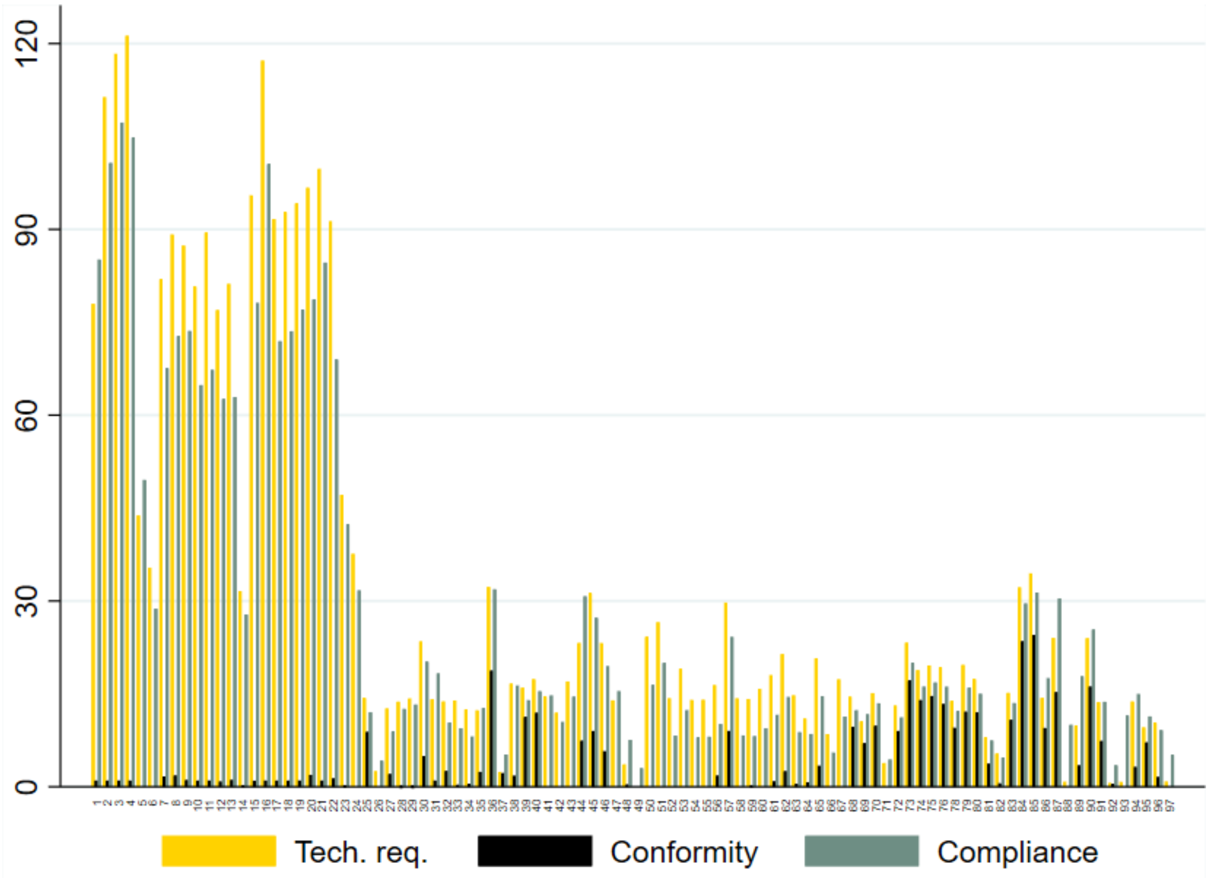
[17] The index for Conformity takes a zero value in 236 out of 330 Pseudo-Regulations, while the indices for Technical Requirements and Compliance take zero values in 30 and 13 Pseudo-Regulations respectively.

[18] It must be stressed that there is no particular reason behind our choice to use the 2012-2018 period for the econometric analysis.

[19] These figures do not exploit the time variation in the data. We compute the 6-digit product product-level indices by summing the regulatory intensity of the Regulations that apply to each product regardless of when they entered into force, then we take a (simple) average across 6-digit products within the 2-digit chapters. There are alternative ways of aggregating the product-level indices to the 2-digit Chapter level. For instance, one could disregard the product dimension within the Chapters, and construct the Chapter-level indices using the unique Regulations applying to the Chapter (e.g. summing, or averaging, the regulatory indices of the Regulations, without double-counting Regulations). We believe that these latter approaches could misrepresent regulatory intensity at the Chapter-level, for instance because there are more products in some Chapters (so, inherently, a larger number of Regulations), or because regulatory restrictiveness applies at the product level, making an average of Regulations at the 2-digit level not desirable either.

Figure 3: Index Count by 2-digit HS chapters



Source: authors' elaboration

We see that, for Technical Requirements and Compliance, the most intensely regulated products are those of the agricultural and food chapters (chapters 1-24), with the remaining chapters still witnessing a significant degree of variation, but at a lower level. For Conformity (black bars), the peaks for regulatory intensity are found in chapters 84 and 85 (mechanical appliances such as boilers, nuclear reactors, and electrical machinery) and chapter 36, explosives and pyrotechnic products. These latter chapters also take high values of regulation in Technical Requirements and Compliance too.

4.1. Additional data requirement

In order to test the effects of regulatory intensity we have extracted data on trade flows and ad-valorem tariffs from UN Comtrade and the UNCTAD TRAINS databases.

The trade data, from Comtrade, span the 2012-2018 period, and have been extracted at the 6-digit HS product level. We use data on imports from all EU countries (separately by each of the 28 members), from all partner countries worldwide (i.e. including both EU and non-EU partners). The tariff data have been extracted from TRAINS, for the same period, and aggregated within 6-digit product groups using a simple unweighted average.

Finally, we use the Hidalgo-Hausmann (2009) index of product complexity for year 2011, available to download at the 4-digit HS level from the Atlas of Economic Complexity website.

5. Empirical methodology

In addition to the novel indices of EU Single Market regulatory intensity, a key contribution of this study is to assess how trade flows respond to the application of the core lists of obligations contained in the EU Regulations. These rules need to be complied with by economic operators intending to place products on the EU Single Market. They therefore apply in a non-discriminatory way to both domestic (EU) producers, and exporters from non-EU countries. The imposition of these requirements can either facilitate trade, if they enable firms to increase the quality of their products, or signal particular attributes (e.g. through labels) that are valued by EU consumers, or hinder trade, if extra-production costs result from compliance with EU rules. To test which effect dominates, we estimate the impact of regulatory intensity on trade in a rigorous partial equilibrium gravity setting.[20]

We face several choices and challenges in the empirical exercise, which are typical of the literature estimating the effects of policies on trade and relate to several well-known endogeneity concerns.

We exploit a 'rectangular' dataset including import flows at the 6-digit level by all 28 EU member countries from all partner countries, including imports from other EU members and non-EU members, over the 2012-2018 period. This therefore includes zero trade flows in the data, which account for approximately 40% of the observations used in estimation after excluding singletons and observations separated by fixed effects. There are also potentially important heteroskedasticity issues due to the presence of several small values of imports, as we work at a very disaggregated level of analysis. We address both these issues by estimating our models with a Poisson Pseudo Maximum Likelihood (PPML) estimator (Santos Silva and Tenreyro, 2006), in line with the recent

[20] We focus on the direct effect of regulatory intensity on trade, and are not concerned with wider general equilibrium effects of product regulation.

literature (e.g., Yotov et al., 2016; Larch et al., 2019). We estimate the model using the PPML estimator developed by Correia et al. (2019).[21]

The estimated effects of our indices of regulatory intensity on trade could be confounded by several omitted factors, and could be biased by reverse causality issues. To address these concerns, our empirical models feature an extensive set of fixed effects: importer-exporter-HS4 group-year, and importer-exporter-HS6 product. These fixed effects capture a large number of trade determinants, both in the cross-section and over time.

The importer-exporter-HS4-year fixed effects capture any time-varying country, country-pair, and country-pair-HS4 group characteristic that can affect imports. These factors include effects of the 2016 Brexit referendum (e.g., trade policy uncertainty over future EU-UK relations), national policies, bilateral agreements such as FTAs, sectoral policies applied on an MFN basis (e.g., investment facilitations or restrictions) or on a bilateral basis (e.g., changes in FTA's Rules of Origin specific up to the 4-digit level), as well as variation in incomes and population. Importantly, these fixed effects also account for the country-level multilateral resistance terms of the gravity equation.

The importer-exporter-HS4-year fixed effects control also for both demand and supply shocks, specific to each country-pair, at the lowest possible level enabling us to estimate the effect of regulatory intensity in absolute terms (i.e. not relatively to a reference group).[22] These fixed effects also attenuate reverse causality concerns due to product regulation arising because of larger trade flows (e.g., changes in regulation applicable at the 4-digit level).

The importer-exporter-HS6 product fixed effects control for any time-invariant factors that can affect trade flows between a pair of countries in a particular HS6 product. These vary from bilateral geographical factors such as distance and transportation costs, to language, relative labour costs, former colonial ties, and similarity in legal systems. Note that these fixed effects also apply to the product dimensions of these factors (e.g., how distance affects trade of perishable versus non-perishable products). Finally, the country-pair-product fixed effect also capture the trade policy endogeneity issue by accounting for the unobservable time-invariant linkages between regulatory intensity and the error term in gravity models (Egger and Nigai, 2015; Yotov et al., 2016).

[21] This estimator allows us to include high-dimensional fixed effect in a PPML estimation.
[22] Exploiting fixed effects at an even lower level, i.e. at the importer-exporter-HS6-year, would completely absorb the variation of our dependent variable.

In our preferred specification, we use both the sets of fixed effects just described. This implies that we estimate the trade effect of *changes* in regulatory intensity over time within 6-digit product codes, while controlling for time-varying confounders that affect importer-exporter-HS4 triplets of heterogenous regulatory intensity differently.

The main estimating equation used to address all the above-mentioned issues is of the following form:

$$EU\ imp_{ijkt} = \exp\left(\beta_1 \ln RII_{kt} + \beta_2 \ln tar_{ijkt} + \delta_{ijst} + \vartheta_{ijk}\right) * \varepsilon_{ijkt} \qquad (1)$$

$EU\ imp_{ijkt}$ denotes the flow of imports by EU member country *i*, from partner *j*, of 6-digit product *k*, in year *t*. $\ln RII_{kt}$ denotes the our regulatory intensity indices at the product-year level. $\ln tar_{ijkt}$ denotes the (log of) ad-valorem tariff rates at the bilateral product-year level. δ_{ijst} and ϑ_{ijk} denote the importer-exporter-HS4-year and importer-exporter-HS6 product fixed effects, respectively; ε_{ijkt} is an idiosyncratic error term. Finally, standard errors clustered at the product (*k*) level, as this is the level of variation of the regulatory indices, are used for inferential purposes.

6. Estimation results

This section presents the results obtained by estimating specification (1) described above. We begin by presenting estimates obtained on the aggregate sample, and by investigating the trade effect of regulation using the simpler versions of our indices i.e. a count of the number of EU Regulations applying to each 6-digit product, and the word count of those Regulations. We then present results obtained using the indices based on the content of Regulations in terms of Technical Requirements, Conformity Assessment, and Compliance. In the next subsection, we investigate some auxiliary hypotheses that help interpreting the main findings.

6.1. Main results

Table 3 presents the results obtained exploiting as indices of regulatory intensity the number of EU Regulations applying to each 6-digit product, and the number of words. In the first two columns, we estimate the effect on EU imports from non-EU countries only, in columns (3) and (4) we exploit the full sample of imports from both EU and non-EU countries. In columns (1) and (3) we estimate specification (1) with importer-exporter-HS4-year fixed effects only, and in columns (2) and (4) we add the importer-exporter-HS6 fixed effects. The latter is our preferred specification, as only time variation is used to estimate the trade effect of the indices, and we insulate our findings better from endogeneity concerns. However, in this section we present results obtained with a less stringent specification too, to show the differences that emerge when some cross-sectional variation is used as well (i.e., between HS6 products within an HS4 group).

Table 3 – Number of Regulations and number of words

	(1)	(2)	(3)	(4)
Dep. Var:	EU Imports			
Imports from:	**Non-EU**		**EU and non-EU**	
Index: number of Regulations				
No. Reg	0.0125	0.0612	0.0018	0.0229
	(0.0092)	(0.0460)	(0.0111)	(0.0353)
No. Reg * Non-EU			0.0106***	0.0345**
			(0.0037)	(0.0139)
Ln(tariff)	-0.258**	-0.0200	-0.258**	-0.0197
	(0.121)	(0.0495)	(0.121)	(0.0494)
Imp-Exp-HS4-Year	Y	Y	Y	Y
Imp-Exp-HS6		Y		Y
Observations	18352361	10166573	34018398	21594980
Index: number of words				
Num. Words	0.000003**	0.000005*	0.0000017	0.0000015
	(0.000001)	(0.000003)	(0.0000017)	(0.0000019)
Num. Words * Non-EU			0.0000014*	0.0000035**
			(0.0000008)	(0.0000014)
Ln(tariff)	-0.265**	-0.0228	-0.265**	-0.0225
	(0.122)	(0.0499)	(0.122)	(0.0499)
Imp-Exp-HS4-Year	Y	Y	Y	Y
Imp-Exp-HS6		Y		Y
Observations	18352361	10166573	34018398	21594980

Notes: Standard errors clustered at the product level in parenthesis; ‘ p<0.15, * p < 0.1, ** p < 0.05, *** p < 0.01.

Table 3 reveals that a higher number of Regulations does not seem to affect of EU imports from non-EU countries. In both columns 1 and 2, the estimated coefficients are positive but lack statistical significance. Note the difference between the two columns, however: adding the import-exporter-HS6 fixed effects makes little difference to the point estimate of the regulatory index (the coefficient increases in size, but remains insignificant), whereas the ad-valorem tariff goes from being a negative and significant determinant of EU imports, to being insignificant. This is due to the removal of the cross-sectional variation when moving from column 1 to column 2, and the limited variation over time in the EU applied tariffs.

In columns 3 and 4 of Table 3 we estimate the impact of a higher number of Regulations on intra-EU trade, and the effect on imports from non-EU countries relative to intra-EU trade. No effect is found on intra-EU trade, but a positive and significant impact is detected on the interaction term picking up the differential effect on imports from non-EU countries. This suggest that an increasing number of Regulations facilitates imports from outside the EU, albeit only in relative terms, compared to imports from inside the block.

In Table 3 we also use our index of Regulatory intensity based the length of the Regulations in terms of number of words. The rationale behind the use of this simple index is that longer Regulations may feature a longer list of requirements, or more complex requirements, and thereby have a larger effect on trade. An example of this is provided in Regulation 2016/1628 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines. However, it is acknowledged that a Regulation may be long in words simply because it covers a wide range of products each of which requires some separate discussion, and in this case, length may not be a good indicator of intensity. An example of the latter kind is Regulation 1308/2013, that establishes a common organization of the markets for agricultural products, and does so listing a long number of different products.[23] The estimation results are similar to those for the number of Regulations, with the addition that now we find a positive and significant impact on EU imports from non-EU countries also in columns 1 and 2, i.e. not only relative to intra-EU trade.[24]

The either nil or positive effects presented in Table 3 are somewhat unexpected, and need to be rationalized. The literature has shown that NTMs can have both positive and negative trade impacts, operating through various channels. We argue that the results on Table 3 are incomplete, as both indices cannot distinguish between different effects arising from the various types of

[23] This Regulation applies to 690 6-digit products.
[24] From here onward on we will not describe the results obtained without imp-exp-HS6 fixed effects but, for completeness, we will report the estimates obtained with and without these fixed effects in the tables in this section.

requirements imposed. It is conceivable that some of the rules that producers need to comply with to place their goods in the Single Market allow them to increase their sales, while other result in extra-costs and administrative burdens which reduce production for the EU. Here below we show that it is crucial to look inside the Regulations and use information on their content, other than their number and word count, in order to disentangle the effects of various different requirements that are imposed on economic operators.

We now explore the effect of regulatory intensity arising when exploiting our indices based on the content of EU Regulations. We present results obtained using the Index Count-syn., which we prefer to the Index Count and the Index Sum as a measure of regulatory intensity given the number of different (non-synonym) keywords might capture better the degree of stringency of a Regulation, as opposed to counting words which might be synonyms of each other, or counting all the instances in which a certain word appears.[25] The results are presented in Tables 4, 5, and 6.

Table 4 – Total of keywords, Index Count-syn.

	(1)	(2)	(3)	(4)
Dep. Var:	EU Imports		EU Imports	
Imports from:	**Non-EU**		**EU and non-EU**	
Tot. Index	0.0023' (0.0015)	0.0098* (0.0056)	0.0005 (0.0018)	0.0047 (0.0045)
Tot. Index * Non-EU			0.0019*** (0.0005)	0.0048*** (0.0015)
Ln(tariff)	-0.259** (0.121)	-0.0204 (0.0491)	-0.259** (0.121)	-0.0202 (0.0491)
Imp-Exp-HS4-Year	Y	Y	Y	Y
Imp-Exp-HS6		Y		Y
Observations	18352361	10166573	34018398	21594980

Notes: Standard errors clustered at the product level in parenthesis; ' $p<0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Before exploiting the indices in the three separate areas, in Table 4 we experiment with an index which aggregates all the (non-synonym) keywords across the areas. This exercise should inform on whether using a *selected* word count, i.e. non-synonym words with 'regulatory meaning', can produce results which differ from those obtained with the simpler indices in Table 3. Estimation

[25] All models have been estimated also with the Index Count and the Index Sum, however, and results are qualitatively very similar. The magnitude of the effect is smaller when using the Index Sum, due to the different scale of the variable. We present the core results obtained with the index Count in the Appendix, as this reassures the reader that our grouping of the keywords does not drive the findings. The results obtained with the Index Sum are available upon request.

results are remarkably similar: an increase in regulatory intensity results in more imports from non-EU countries, both in absolute terms (column 2) and relative to intra-EU trade (column 4). The latter is again found to be unaffected by EU Single Market regulation. Hence, an index based on the aggregate regulatory content of legislative acts does still not appear to yield qualitatively different information compared to less sophisticated measures based on a mere count of Regulations, or their words without distinction of their meaning (i.e. all words). This points once again to the importance of investigating the effects of regulatory intensity separately across areas.

Tables 5 and 6 present the core results of this paper. We use the three indices in the areas of Technical Requirements, Compliance, and Conformity Assessment jointly to assess whether different types of obligations about production methods, testing, checks, etc, have heterogeneous trade impacts. Table 5 presents the results for EU imports from non-EU countries only; Table 6 shows results for imports from both EU and non-EU countries. Starting from Table 5, Technical production requirements are unambiguously found to have a positive impact on imports from non-EU countries in all the specifications: using the estimates in column (8), an increase of one key-word group in Technical Requirements leads to an increase in imports of approximately 8%. Compliance and Conformity Assessment take the opposite sign. An increase of one keyword group in Compliance leads to a decline in EU imports of approximately 4.7%; for Conformity Assessment the impact is smaller, -1.23%, although this coefficient obtained on the aggregate sample lacks significance. These are sizeable effects. Note, however, that a marginal change in Index Count-Syn is more substantial compared to a change in the versions of our Indices where keywords are not grouped. As a comparison, using the simpler Index Count (Table A2 in Appendix, Column 4), the trade impact of a one keyword increase in the indices in Technical Requirements, Compliance and Conformity Assessment are +3.8%, -1.53% and -0.76%, respectively.

In Table 6, we find that changes in regulatory intensity have effects also for imports from intra-EU origins. The effect is positive for Technical requirements, negative for Compliance, and insignificant for Conformity Assessment. Similarly to Tables 3 and 4, we estimate the relative impact on imports from non-EU countries too. All three areas are now found to exhibit a significant trade impact: imports from non-EU countries are affected positively by increases in Technical Requirements, and negatively by increases in Compliance and Conformity Assessment obligations. Note that summing the coefficients by area in Table 6, we obtain roughly the coefficients in absolute terms of Table 5.[26]

Table 5 – Indices by separate regulatory areas, Non-EU countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var:				EU Imports				
Imports from:				**Non-EU**				
Tech. req.	0.008**	0.039**	0.013***	0.050*	0.026**	0.072***	0.029**	0.077***
	(0.004)	(0.015)	(0.004)	(0.026)	(0.013)	(0.024)	(0.013)	(0.023)
Compliance		-0.029**		-0.042'		-0.047***		-0.048***
		(0.014)		(0.027)		(0.017)		(0.017)
Conf. Ass.			-0.014*	0.012			-0.007	-0.012
			(0.008)	(0.016)			(0.011)	(0.009)
Ln(tariff)	-0.266**	-0.279**	-0.273**	-0.280**	-0.018	-0.010	-0.017	-0.008
	(0.122)	(0.126)	(0.124)	(0.126)	(0.048)	(0.047)	(0.048)	(0.047)
Imp-Exp-HS4-Year	Y	Y	Y	Y	Y	Y	Y	Y
Imp-Exp-HS6					Y	Y	Y	Y
N	18352361	18352361	18352361	18352361	10166573	10166573	10166573	10166573

Notes: Standard errors clustered at the product level in parenthesis; ‘ p<0.15, * p < 0.1, ** p < 0.05, *** p < 0.01.

To the best of our knowledge, the joint estimation of these effects is novel to the literature on the trade impacts of *behind the border* NTMs. Several previous works investigated in depth the role of product standards (SPS and TBT), with a majority of works finding negative trade effects. Among our three indices, the role of standards is best captured by Technical Requirements: we acknowledge that both positive and negative channels can explain the trade effect of this area of regulation, but we consistently estimate a positive (net) trade impact. Fewer works also assess the role of certification and testing requirements (e.g., Chen et al. 2008; Crivelli and Gröschl, 2016), which we capture with our index on Conformity Assessment. Here our results are aligned with the literature, as we find a negative impact of this index is (almost) all our specifications. Importantly, we are not aware of previous works testing explicitly the role of Compliance next to that of the other two areas of regulation, which we show having a strong trade deterrent effect. However, as our index captures also the effect of customs and border controls, our finding of a negative trade impact for Compliance is related to similar effects reported by the literature on trade facilitation (e.g., Volpe Martincus et al, 2015; Carballo et al., 2024).

[26] This not surprising, however, given that the structure of the fixed effects nests the country groups used to define the interaction terms in Table 6.

Table 6 – trade effects of regulatory intensity: separate areas, EU and Non-EU countries

	(1)	(2)
Dep. Var:	EU Imports	
Imports from:	**EU and non-EU**	
Tech. req.	0.0321	0.0346**
	(0.0252)	(0.0153)
Compliance	-0.0196	-0.0245***
	(0.0275)	(0.0075)
Conf. Ass.	-0.0127	0.00514
	(0.0187)	(0.0058)
Tech. req. * Non-EU	0.0180*	0.0413***
	(0.0108)	(0.0123)
Compliance * Non-EU	-0.0227*	-0.0239*
	(0.0125)	(0.0127)
Conf. Ass. * Non-EU	0.0248**	-0.0153**
	(0.0098)	(0.0073)
Ln(tariff)	-0.280**	-0.0082
	(0.126)	(0.0472)
Imp-Exp-HS4-Year	Y	Y
Imp-Exp-HS6		Y
N	34018398	21594980

Notes: Standard errors clustered at the product level in parenthesis; ‘ p<0.15, * p < 0.1, ** p < 0.05, *** p < 0.01.

Having established the main trade effects of more intense regulation as captured by our indices in the aggregate sample, we show the differential effects by countries depending on their income per capita. The literature has often shown that developing countries tend to be more adversely affected by NTMs, especially those applied by developed or high-income economies. The rationale is that more demanding product standards or testing procedures are harder to comply with or lead to larger cost increases for developing countries' exporters. Firms in high-income countries should instead be less affected, or be able to take advantage of more stringent standards to improve product quality and expand their sales. A number of works have found negative impacts of NTMs in high-income economies too, however. To investigate whether this dichotomy is found also in the setting of our analysis, we simply use a binary variable separating non-EU countries in high-income and non-high-income[27], and we then interact this with the indices of regulatory intensity. Estimation results are presented in Table 7.

[27] We have used the 2022 version of the World Bank income per-capita classification

Table 7 – **separate areas of regulation, by high- and non-high-income countries**

	(1)	(2)
Dep. Var:	EU Imports	
Imports from:	**Non-EU**	**EU and Non-EU**
Tech. req.		0.0348**
		(0.0153)
Compliance		-0.0249***
		(0.0074)
Conf. Ass.		0.0052
		(0.0058)
Tech. req. * non-HI	0.0422*	0.0074
	(0.0219)	(0.0104)
Tech. req. * HI	0.0938***	0.0551***
	(0.0241)	(0.0123)
Compliance * non-HI	-0.0099	0.0149
	(0.0162)	(0.0117)
Compliance * HI	-0.0688***	-0.0424***
	(0.0146)	(0.0116)
Conf. Ass. * non-HI	-0.0220*	-0.0272***
	(0.0119)	(0.0101)
Conf. Ass. * HI	-0.0053	-0.0061
	(0.0087)	(0.0077)
Ln(tariff)	-0.0071	-0.0076
	(0.0468)	(0.0469)
Imp-Exp-HS4-Year	Y	Y
Imp-Exp-HS6	Y	Y
Observations	10166573	21594980

Notes: Standard errors clustered at the product level in parenthesis; ‘ $p<0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The difference between the effect on imports from high- and non-high-income income countries is not homogenous across the three areas of regulation. In column (1) we estimate the effects in absolute terms, in column (2) we estimate the effects relative to intra-EU trade. Technical Requirements are found to stimulate EU imports from both groups of countries, but more so from high-income economies. Imports from the latter appear to benefit from higher Technical Requirements also relative to intra-EU trade, whereas non-high-income countries do not. This finding is compatible with the rationale mentioned above, i.e. that firms in wealthier countries are better able to conform to new production procedures and standards, such that the overall net trade impact of these requirements can be positive.

For Compliance, we find that the negative effect on EU imports estimated in the aggregate sample (Tables 5 and 6) is entirely driven by imports from high-income countries. The checks, controls, authorizations, and other barriers to transit imposed on products exported by high-income countries are likely to be more demanding than those applied to products from less wealthier economies, and we conjecture this might be explained by the complexity[28] of the goods exported. We will test this more explicitly in Table 8 below. Also, the negative effect of Compliance on imports from high-income non-EU countries is larger than that estimated for intra-EU trade, as evidenced from the negative interaction term in Column 2.

Lastly, for Conformity Assessment we find a negative trade impact on imports from non-EU countries only: this latter subsample is where the effect of Conformity Assessment is found to be statistically significant (it is insignificant in the aggregate sample), both in absolute terms (Column 1) and relative to intra-EU trade (Column 2). Note, also, that only this area of regulation is found to be a trade deterrent for developing countries: EU product testing and certification rules seem to be the main regulatory issue for producers in poorer economies, such that increasing these requirements results less trade directed to the EU.

There are some important take-aways from this section. First, do not find overwhelmingly negative impacts of product regulation; if anything, when we exploit indices which do not distinguish between different areas of regulation, the estimated trade effect is either nil, or positive. Second, it is crucial to estimate separate effects for different types of requirements imposed on firms: in line with part of the literature (Chen et al., 2008; Crivelli and Gröschl, 2016; Curzi et al, 2020), we find positive effects for Technical requirements and negative effects for Conformity Assessment.[29] Furthermore, we provide novel insights on the relevance of Compliance requirements, the area of our indices that yields most consistently negative trade impacts of regulation on EU imports from both EU and non-EU partners. These results are consistent with our expectations but, to the best of our knowledge, are new to the literature examining the effects of NTMs arising from EU Single Market regulation.[30] Third, heterogeneity exists across countries at different levels per-capita income, but the trade impacts of regulation differ in non-obvious ways. In contrast with the extant literature, we find both positive and negative effects of regulation for both high- and non-high-

[28] As captured by the number of production stages concurring to make the traded good.

[29] Some of these studies find positive effects only at the intensive margin, however.

[30] Unpublished work by Flach, Teti and Scheckenhofer (2023) assesses the trade effects of specific post-Brexit compliance requirements arising from documents that UK traders need to exhibit at the border when exporting their products to the EU. They also find strong negative effects, although their work differs from ours in several key respects. They construct a different measure of NTMs (based on the number of documents that need to accompany shipments crossing the EU border), specific to custom checks, and study a particular shock and time period.

income countries. The effects vary across area of regulation. Technical requirements affect EU imports from both groups positively, but more so when originating in high-income trade partners. Compliance and Conformity Assessment are trade dampening: the former for high-income countries, the latter for non-high-income countries.

6.2. Auxiliary hypotheses – product complexity and 'investment incentives'

To corroborate our analysis, and provide additional results that can help us interpret our findings so far, we now investigate more in detail two additional hypotheses: how the trade effects of regulation vary depending on product attributes such as product complexity, and on the relevance of the NTM-imposing market from the perspective of the exporter country.

6.2.1. Product complexity

Product complexity, resulting from the degree of sophistication of the production process, is a good contender for being a driver underlying some of our empirical results. Products requiring particularly advanced techniques, or that undergo several transformative steps in the production process, might suffer from larger increases in production costs as a result of new regulations that impose specific technical requirements.

We investigate this hypothesis by exploiting the widely used index of product complexity developed by Hidalgo and Hausman (2009). We separate the products in our sample in groups corresponding to quartiles of the complexity distribution (as calculated for year 2011 – one year prior to the start of our observation period – in order for the partition of products to be more exogenous in estimation), and interact dummies for each complexity quartile with the indices of regulatory intensity. Estimation results are presented in Table 8.

Starting from the aggregate sample (column1), in line with our expectations, we find that the trade effects of EU regulation are strongly driven by the products in the top quartile, i.e. those characterized by the highest complexity. For Technical Requirements this result is very neat, as the positive effect grows monotonically along the complexity distribution, and becomes large and very precisely estimated on the fourth quartile. For Compliance and Conformity Assessment we also find that the most complex products are those whose EU imports are most negatively affected by these areas of regulation.

Table 8 – The role of product complexity

	(1)	(2)	(3)
Dep. Var:		EU Imports	
Imports from:		**Non-EU**	
Sample	All non-EU	Non-high-income	High Income
Technical requirements			
1st complexity Q.	-0.0067	-0.0035	-0.0116
	(0.0085)	(0.0086)	(0.0139)
2nd complexity Q.	0.0001	0.0101	0.0004
	(0.0090)	(0.0162)	(0.0085)
3rd complexity Q.	0.0416*	0.0359	0.0708**
	(0.0218)	(0.0251)	(0.0336)
4th complexity Q.	**0.132*** **	**0.0832*** **	**0.140*** **
	(0.0301)	**(0.0288)**	**(0.0293)**
Compliance			
1st complexity Q.	0.0188*	0.0221**	0.0133
	(0.0097)	(0.0099)	(0.0122)
2nd complexity Q.	-0.0083	-0.0006	-0.0249'
	(0.0145)	(0.0186)	(0.0166)
3rd complexity Q.	-0.0340	-0.0288	-0.0681*
	(0.0299)	(0.0383)	(0.0397)
4th complexity Q.	**-0.0690*** **	0.0137	**-0.0820*** **
	(0.0192)	(0.0152)	**(0.0162)**
Conformity Assessment			
1st complexity Q.	-0.0420**	-0.0505**	-0.0085
	(0.0178)	(0.0200)	(0.0075)
2nd complexity Q.	0.0368*	0.0041	0.0809***
	(0.0217)	(0.0237)	(0.0231)
3rd complexity Q.	-0.0095	0.0051	-0.0140
	(0.0134)	(0.0231)	(0.0118)
4th complexity Q.	**-0.0598** **	**-0.108*** **	-0.0548**
	(0.0269)	**(0.0295)**	(0.0266)
Ln(tariff)	0.0051	0.0083	-0.0242
	(0.0462)	(0.0452)	(0.0762)
Imp-Exp-HS4-Year	Y	Y	Y
Imp-Exp-HS6	Y	Y	Y
N	10166573	5971415	4195158

Notes: Standard errors clustered at the product level in parenthesis; ' p<0.15, * p < 0.1, ** p < 0.05, *** p < 0.01.

Interestingly, when we re-estimate these models separately for imports from High-Income and Non-High-Income countries (columns 2 and 3), we find that the role of product complexity is most evident in the area of regulation which, in the aggregate sample, affects imports from the group of countries the most. Put differently, for High-Income countries, the most complex products drive the trade effects of Technical Requirements and Compliance; for Non-High-Income countries, the most complex products drive the impact of Conformity Assessment.

The results presented in Table 8 comprise, to the best of our knowledge, a relatively new finding for the literature on the trade impact of NTMs. In Table A1 in Appendix we show that the role of product complexity in driving the trade effect of higher regulation is found also for intra-EU trade, and for imports from non-EU countries relative to intra-EU trade. In Table A1 we estimate four separate models, for each of the complexity quartiles, rather than exploiting interactions with the regulatory indices as done in Table 8. This is so that we can compare more easily the effects on non-EU countries relative to intra-EU trade. Note, however, that the coefficients in columns 1-4 of Table A1 are very similar to those in column 1 in Table 8: this is due to the fixed effects structure that we exploit, and it reassures us that either approach (using interactions or splitting the sample) yields the same estimation results.

6.2.2. Investment incentives

Next, we investigate whether the trade impact of regulation depends on the importance of the regulation-imposing market from the perspective of the exporter country. We refer to this hypothesis as 'investment incentives' because, on the one hand, if the EU represent a sizeable share of a country's total exports, producers might be inclined to make the investments necessary to comply with the new Single Market rules. If, on the other hand, the EU is a relatively less important export destination, producers might be less prone to adapt their products to new regulation to maintain their level of sales in that market.

In terms of trade impacts, we expect that this hypothesis should apply mainly to the areas of regulation that we found to be trade dampening, i.e. Compliance and Conformity Assessment. EU imports should contract more (less) in response to increases in Compliance and Conformity Assessment requirements when originating in partners for which the EU is a relatively less (more) important export destination. For Technical Requirements, that in this work we find to be trade enhancing, this hypothesis could not apply in the same way. For instance, it is conceivable that the opposite effect could be found. New requirements enabling exporters to grow their sales in the

EU could be met by a stronger positive production and trade response in countries for which the EU is not yet a core export destination, as this could represent an opportunity to expand sales in a large and wealthy economy.

To investigate this hypothesis, we compute the share of exports to the EU out of total exports for each non-EU country in our dataset.[31] We then compute quartiles of the export-share distribution, construct four binary variable denoting countries assigned to each quartile, and interact these variables with the regulatory intensity indices. The empirical findings are presented in Table 9.

Starting from the trade-dampening areas of regulation, for Compliance and Conformity Assessment we find that the trade response to changes in regulation is stronger in the lower quartiles of the export-share distribution. This is in line with our expectations of trade from countries for which the EU is a less important destination being more deterred by increases in regulation. In column 1 this result is more evident for Compliance, for which the coefficient estimated on the first export-share quartile is largest and statistically more significant than those estimated on the other three quartiles. Looking across the columns, we find that the effects for Compliance are, once more, driven by the High-Income countries. For Conformity Assessment, in column 1 the largest and (only) statistically significant coefficient is estimated on the third quartile; however, for Non-High-Income countries, which is the subsample for which Conformity Assessment is found to be a trade barrier (see Tables 7 and 8 above), we very clearly see that the largest trade dampening impact is found on the first quartile of the export-share distribution. Overall, for both these areas of regulation we find that imports from countries in the top quartile, i.e. those for which the EU is an important destination, are completely unaffected by changes in regulation. This is compatible with our hypothesis that countries relying on the EU for the export sales would make the necessary adjustments to comply with EU rules and continue to serve the Single Market.

For Technical Requirements, that throughout this work we find to be trade-enhancing, our ex-ante priors about the how trade effects could vary along the export-share distribution are less clear-cut. From Table 9 it appears that increases in Technical Tequirements lead to an increase in EU imports in particular from countries in the lower export-shares quartiles; i.e. trade from countries for which the EU is a relatively unimportant market responds more strongly to increases in this area of regulation. This is driven by High-Income countries and, as a tentative explanation, we

[31] This is computed with data for 2012 from UN Comtrade, accessed through the World Bank WITS website.

conjecture that Technical Requirements might be spurring those exporters relatively that are less engaged with the EU to expand their sales in this large market.

Table 9 – Investment incentives

	(1)	(2)	(3)
Dep. Var:		EU Imports	
Imports from:		**Non-EU**	
Sample	All non-EU	Non-high-income	High Income
Technical requirements			
1st export share Q.	0.129***	0.0585'	0.123***
	(0.0379)	(0.0399)	(0.0355)
2nd export share Q.	0.0786***	0.0109	0.105***
	(0.0206)	(0.00822)	(0.0225)
3rd export share Q.	0.0767**	0.116**	0.0209
	(0.0342)	(0.0479)	(0.0185)
4th export share Q.	0.0089	-0.0045	0.0162**
	(0.0065)	(0.0125)	(0.0068)
Compliance			
1st export share Q.	-0.0721***	-0.0141	-0.0768***
	(0.0239)	(0.0269)	(0.0245)
2nd export share Q.	-0.0474**	0.0169'	-0.0750***
	(0.0185)	(0.0109)	(0.0138)
3rd export share Q.	-0.0403**	-0.0753**	-0.0270
	(0.0194)	(0.0352)	(0.0211)
4th export share Q.	-0.0043	0.0066	-0.0104*
	(0.0054)	(0.0108)	(0.0057)
Conformity Assessment			
1st export share Q.	-0.0187	-0.0779***	0.0313
	(0.0219)	(0.0255)	(0.0304)
2nd export share Q.	-0.0187'	-0.0302**	-0.0062
	(0.0118)	(0.0125)	(0.0132)
3rd export share Q.	-0.0304*	0.00438	0.0048
	(0.0161)	(0.0312)	(0.0137)
4th export share Q.	0.00484	0.00752	-0.0078
	(0.0146)	(0.0165)	(0.0127)
Ln(tariff)	-0.0034	0.0050	-0.0264
	(0.0465)	(0.0453)	(0.0757)
Imp-Exp-HS4-Year	Y	Y	Y
Imp-Exp-HS6	Y	Y	Y
N	10166573	5971415	4195158

Notes: Standard errors clustered at the product level in parenthesis; ‘ p<0.15, * p < 0.1, ** p < 0.05, *** p < 0.01.

7. Conclusion

This paper contributes to the large literature on the trade impacts of technical Non-Tariff Measures (NTMs) such as SPS and TBT, providing a new set of indices by which regulatory intensity in the EU Single Market can be measured, together with an array of novel empirical results which inform on the effects of domestic product regulation on international trade.

We present a novel set of indices of regulatory intensity for the EU Single Market at the 6-digit HS level constructed using the textual content of 257 EU Regulations and Directives in terms of Technical Requirements, Conformity Assessment, and Compliance. Our indices reveal that EU regulation has rapidly increased from the early 2000s and is very heterogeneous across sectors. For Technical Requirements and Compliance requirements, the most regulated products are those in the food and agricultural sectors, whereas for Conformity Assessment we find that electrical machinery and advanced appliances such as boilers and nuclear reactors comprise the most regulated products.

We then estimate a gravity model with an extensive array of fixed effects to test the trade effects arising from the application our novel measure of NTMs specific to the EU Single Market. The main finding is that the three areas of regulation have heterogenous impacts on EU imports from both EU and non-EU countries: positive for Technical Requirements, and negative for Compliance and Conformity Assessment. To understand the variegated repercussions that product regulation has on production and trade, it is therefore crucial to go beyond aggregate measures such as a count of legislative acts (or a wordcount within the document) that ignore information on the different types of obligations that are imposed on economic operators.

We then present some additional novel empirical findings. Across income per capita groups, we show that imports from high-income countries are more stimulated by increases in Technical Requirements than imports from other (non-high-income) non-EU countries. The negative impacts of Compliance and Conformity Assessment are instead not-uniform across these country groups: Compliance only affects imports from High-Income countries, and Conformity Assessment only affects imports from Non-high-income countries.

To corroborate these results, we explore to two additional hypotheses. First, we argue that more complex products could face proportionately higher costs and obtain larger benefits from compliance with EU Single Market rules. In support of this hypothesis we find that the trade impacts of regulation are driven by products in the top quartile of the product complexity distribution, for all three the areas captured by our indices.

Second, we explore whether heterogeneity in the relevance of the EU, the regulation-imposing market, as an export destination can provide insights on how non-EU countries respond to the application of *behind-the-border* NTMs. For the trade-dampening areas of regulation, i.e. Compliance and Conformity Assessment, increases in regulatory intensity result in a larger contraction of EU imports from countries for which the EU is an unimportant export destination. Vice-versa, imports from countries for which the EU is an important market are completely unaffected. This suggests that adherence to possibly cost-increasing EU regulation is directly proportional to the incentive that non-EU producers have to keep serving the Single Market. Interestingly, we find a similar pattern also for Technical Requirements, with imports from high-income countries for which the EU account for a small export-share to increase the most: this is not an expected result, as in this work Technical Requirements are found to be trade-enhancing, rather than trade-dampening. We believe this can be an indication of the opportunity created by new production requirements, which allow high-income countries for which the EU is not (yet) an important destination to grow their sales in this market.

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Appendix

Table A1: Role of product complexity – imports from EU and non-EU countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var:				EU Imports				
Imports from:		**Non-EU**				**EU and Non-EU**		
Complexity quartile	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Tech. req.	-0.0069	0.0001	0.0403*	0.132***	0.0022	-0.0054	0.0138	0.0588***
	(0.0085)	(0.0090)	(0.0224)	(0.0301)	(0.0036)	(0.0073)	(0.0149)	(0.0215)
Compliance	0.0190*	-0.0083	-0.0326	-0.0694***	-0.0003	0.0044	-0.0261	-0.0295***
	(0.0097)	(0.0145)	(0.0306)	(0.0192)	(0.0031)	(0.0111)	(0.0186)	(0.0063)
Conf. Ass.	-0.0420**	0.0368*	-0.0088	-0.0603**	-0.0032	0.0073	0.0152	-0.0194
	(0.0178)	(0.0217)	(0.0132)	(0.0268)	(0.0070)	(0.0135)	(0.0128)	(0.0155)
Tech. req. * Non-EU					-0.0068	0.0040	0.0260*	0.0733***
					(0.0080)	(0.0092)	(0.0150)	(0.0167)
Compl. * Non-EU					0.0162*	-0.0096	-0.0081	-0.0400**
					(0.0089)	(0.0128)	(0.0196)	(0.0181)
Conf. Ass. * Non-EU					-0.0412***	0.0258	-0.0212'	-0.0406**
					(0.0126)	(0.0198)	(0.0139)	(0.0196)
tar	0.0262	0.0003	-0.0798	0.0381	0.0258	0.0003	-0.0798	0.0381
	(0.0492)	(0.0438)	(0.0919)	(0.0871)	(0.0492)	(0.0438)	(0.0919)	(0.0871)
Imp-Exp-HS4-Year	Y	Y	Y	Y	Y	Y	Y	Y
Imp-Exp-HS6	Y	Y	Y	Y	Y	Y	Y	Y
N	2779044	1550294	2382267	3454968	5613877	3641188	5268377	7071538

Notes: Standard errors clustered at the product level in parenthesis; ‘ p<0.15, * p < 0.1, ** p < 0.05, *** p < 0.01.

Results obtained with the Index Count; i.e. without grouping keywords into synonyms clusters.

Table A2: total of Indices Count

	(1)	(2)
Dep. Var:	EU Imports	EU Imports
Imports from:	Non-EU	EU and non-EU
Tot. Index - Count	0.0041'	0.0019
	(0.0026)	(0.0019)
Tot. Index – Count * Non-EU		0.0021***
		(0.0008)
Ln(tariff)	-0.0210	-0.0209
	(0.0495)	(0.0495)
Imp-Exp-HS4-Year	Y	Y
Imp-Exp-HS6	Y	Y
Observations	10166573	21594980

Notes: Standard errors clustered at the product level in parenthesis; ‘ p<0.15, * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A3: effects by separate areas – indices Count

	(1)	(2)	(3)	(4)
Dep. Var:		EU Imports		
Imports from:		**Non-EU**		
Tech. req.	0.0141*	0.0342**	0.0164*	0.0373**
	(0.00755)	(0.0150)	(0.00851)	(0.0152)
Compliance		-0.0151**		-0.0155**
		(0.00766)		(0.0076)
Conf. Ass.			-0.0064	-0.0077**
			(0.00464)	(0.0038)
Ln(tariff)	-0.0181	-0.0092	-0.0160	-0.0062
	(0.0484)	(0.0468)	(0.0480)	(0.0465)
Imp-Exp-HS4-Year	Y	Y	Y	Y
Imp-Exp-HS6	Y	Y	Y	Y
N	10166573	10166573	10166573	10166573

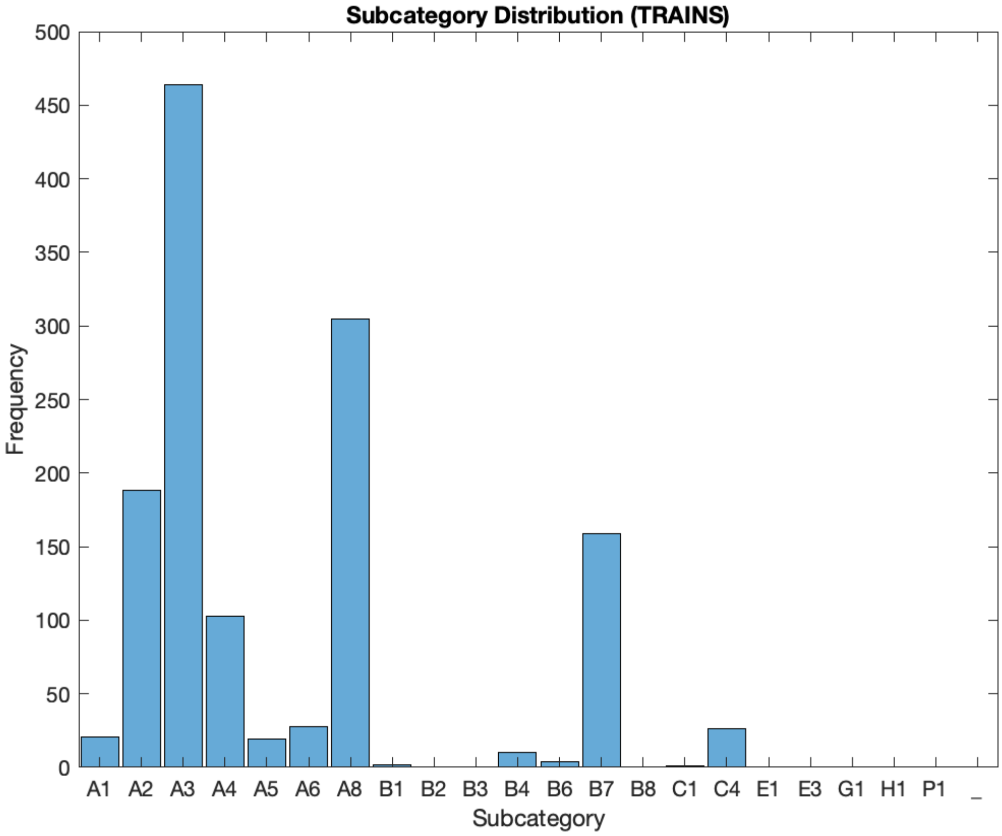
Notes: Standard errors clustered at the product level in parenthesis; ‘ p<0.15, * p < 0.1, ** p < 0.05, *** p < 0.01.

Index construction validation exercise

To confirm the validity of our methodology and the selection of key terms used to identify Non-Tariff Measures (NTMs), we train a text classification algorithm using deep learning techniques. By means of ‘out-of-sample’ prediction, this algorithm assigns the pre-determined TRAINS categories to the content of the 257 Directives and Regulations found in the Protocol. The goal is to determine whether there is a correspondence between these pre-determined categories and the ones we are proposing.

The UNCTAD-TRAINS dataset is used to train our text classification algorithm. This dataset provides a comprehensive overview of NTMs enforced between countries, classified into several categories, and further divided into sub-categories for a more granular analysis of trade regulations. A unique advantage of this dataset is that each NTM is paired with a brief text snippet, extracted from the legislative documents that led to the identification of the NTMs. Consequently, these data could be used to inform the algorithm about the specific words, structures, and patterns that better represent each of the UNCTAD categories.

Figure A1: Distribution across subcategories TRAINS dataset



A1 - Prohibitions/restrictions of imports for sanitary and phytosanitary reasons. A2 - Tolerance limits for residues and restricted use of substances (SPS & TBT). A3 - Labelling, marking, and packaging requirements (SPS & TBT). A4 - Hygienic requirements related to sanitary and phytosanitary conditions. A5 - Treatment for elimination of plant and animal pests and disease-causing organisms in the final product or prohibition of treatment.	A6 - Other requirements relating to production or post-production processes A8 - Conformity assessment (SPS & TBT). B1 - Import authorization/licensing related to technical barriers to trade. B4 - Production or post-production requirements. B6 - Product identity requirements.	B7 - Product quality, safety, or performance requirements. C1 - Pre-shipment inspection. C4 - Import monitoring, surveillance, and automatic licensing measures.

We train a long short-term memory (LSTM) network using a sample that contains 1,330 text documents spanning 16 subcategories (Figure A1). Given that these algorithms employ differentiable functions, they can only process numeric tensors and thus the text data should be transformed and processed. Several intermediate steps are implemented:

1. The documents are randomly divided into training and validation subsets, with a 30% holdout for validation.

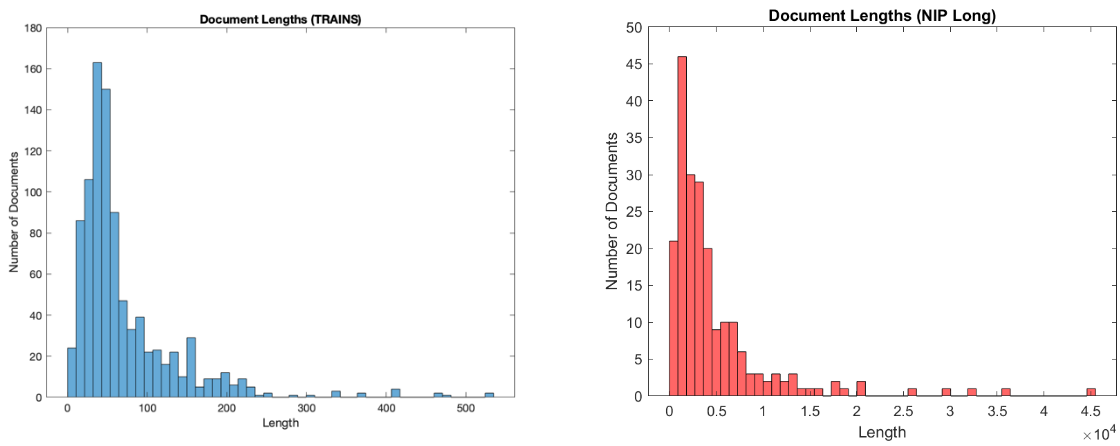
2. Text is standardised: all letters are converted to lower case, punctuation is removed, words of less than two letters are excluded, and the text is then lemmatised.
3. The text is tokenized, and the words are converted into numeric sequences using a word encoding.
4. The tokenized documents are normalized (either truncated or padded) so the numeric sequences have the same length.

The trained network exhibits commendable validation accuracy, predicting the correct subcategory in 83.1% of the documents from the training sample.

The next phase involves using this trained network to assign an UNCTAD category to the Protocol's directives and regulations, by means of 'out-of-sample' predictions. One important limitation, however, is that these documents are considerably lengthier than those in the UNCTAD dataset (Figure A2).

To overcome this issue, we adopted the "PageRank" algorithm, typically used to rank web pages in search engine results, to produce summaries from the directives and regulations. We further adapt the algorithm to pre-filter paragraphs that included at least one key term from each of our three categories: technical requirements, conformity assessment, and compliance, thus producing three separate summaries per document.

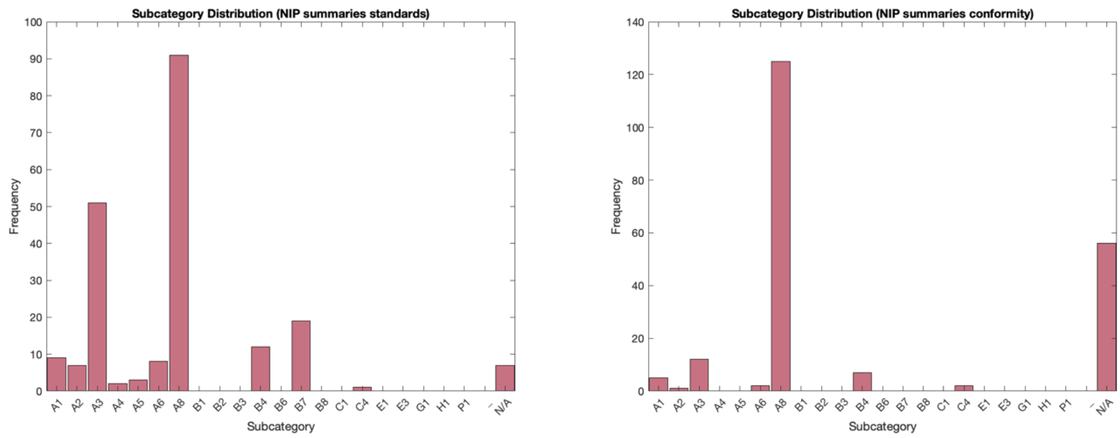
Figure A2: Distribution of the number of tokens in the TRAINS and NIP documents

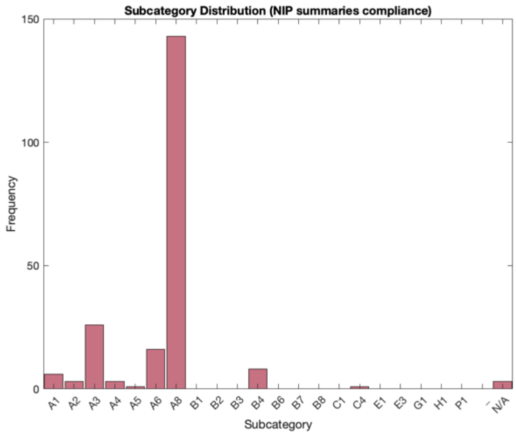


Once the documents are summarized and pre-filtered by categories, we classify them using the trained LSTM network. Below, in Figure A3, we present the distribution of the predicted sub-categories of the NIP summary documents by category. It is reassuring to see that the predicted TRAINS subcategories of the pre-filtered documents generally align with our own categories. For instance, notice how for most of the time the predicted subcategory of documents incorporating terms from our "Conformity" category is "A8 - Conformity Assessment". Similarly, for documents containing terms from our "Technical requirements" category, the predicted TRAINS subcategories are primarily "A8 - Conformity Assessment", "A3 - Labelling, Marking, and Packaging Requirements", and "B7 - Product Quality, Safety, or Performance Requirements". For our "Compliance" category, in most cases, the predicted subcategory was "A8 - Conformity Assessment", with a lesser frequency of "A3 - Labelling, Marking, and Packaging Requirements" and "A1 - Prohibitions/Restrictions of Imports for Sanitary and Phytosanitary Reasons". Although this result may seem puzzling, upon closer inspection, the 3-digit codes assigned to the subcategory "A8 - Conformity Assessment" do bear some resemblance to our "Compliance" category. Such 3-digit codes include:

- Inspection requirements
- Traceability requirements
  - Distribution and location of products after delivery
  - Processing history
  - Origin of materials and parts
- Testing requirements
- Product registration and approval requirement

Figure A3: Distribution of predicted categories across summaries of NIP documents





In conclusion, the validation exercise suggests that there exists a significant overlap between our categorization and the UNCTAD TRAINS dataset's classification of NTMs. This high degree of similarity reinforces the robustness and validity of our categorization approach.