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Environmental trade protection and business perceptions

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Abstract

Environmental trade protection is being increasingly integrated, through technical measures, in regulatory regimes across countries. The resulting regulatory stringency has a critical influence on business competitiveness, their export capacity, and positioning in global value chains. Yet there is no clear consensus on how businesses perceive these regulations. Using a mixed methods approach, we investigate how business perceptions on the stringency of regulations align with the likely trade effects of environmental regulations in the UK. First, we use secondary data on technical measures for environmental protection and bilateral trade to ascertain regulatory stringency across sectors. Second, we use information from the UK Business perceptions survey to understand overall business attitudes towards the government's approach to regulation for access to international trade opportunities. To focus on the UK chemicals sector, we analyse recent news articles and use semi-structured engagement with business actors to validate sector-specific insights. Our analysis shows the likely sectors in the UK the most exposed to technical measures for environmental protection based on their stringency and the alignment between such stringency and business perceptions. We observe the highest degree of regulatory stringency in chemicals and machinery, with organic chemicals and mechanical machinery most strategic for the UK. Overall, business response to stringency appears to depend largely on export destinations. Triangulating across our findings, we find an expansionary pro-trade effect for the UK from regulatory alignment using data from 2010-2020; however, it becomes clear that with Brexit in 2020, businesses expected a major impediment from the government's plans to transpose EU chemical regulatory system REACH (registration, evaluation, authorization, and restriction of chemicals) into UK law. Yet UK chemical exports performed better than expected in the immediate period following Brexit as regulations remained in-line with EU rules during the implementation period in 2021. However, since then, the risk of regulatory divergence emerged with consequent concerns about higher compliance costs with new data-sharing agreements. As of 2024 and even in 2025, the UK business outlook for the UK chemical industry was substantively pessimistic, with continuing concerns of effects of UK's exit from the EU.

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Non-Technical Summary

Environmental trade measures are emerging as a powerful-and contested-tool in global trade. They can push firms to adopt greener practices, align markets with sustainability goals, and contribute to climate action. But they can also raise costs, fragment markets, and exclude firms least able to cope, deepening global trade inequalities. How the regulatory stringency created by these barriers is impacting global trade is still understudied. Equally important is how businesses perceive these measures, whether as enablers of opportunity or as burdens of compliance, which can shape their responses and ultimately the effectiveness of environmental trade policy.

Environmental technical barriers to trade (TBTs) are regulations that set environmental standards for goods entering a market. These regulations are shaping what can be sold across borders as they become increasingly adopted in global trade. A notable example is the EU's Deforestation Regulation (EUDR), which mandates proof of legal and deforestation-free production for commodities entering the EU market. These rules are meant to cut deforestation, curb pollution, and encourage sustainable production. However, they are also creating new barriers for firms in producing countries, particularly those who are least able to bear the costs. This form of environmental trade protection is both an opportunity and a challenge: it can be a driver of sustainability, but also deepen inequalities in global trade.

What are environmental TBTs and why do they matter?

As per the World Trade Organisation, TBTs cover regulations about a product's characteristics, how it is made, the certifications it must hold, as well as testing and inspection procedures required before it can enter a market. These are legal trade measures that can be used for different purposes, for example, environmental protection. These measures can target things like production processes, harmful chemicals, emissions, or waste. Environmental TBT's don't necessarily ban products outright but increase the number of conditions they must meet.

The incidence of environmental TBT's notified to the WTO is increasing, leading to regulatory stringency. Our research indicates that sectors such as chemicals and mechanical machinery are particularly affected by these measures. In chemicals, for example, there were 2,111 environmental TBTs in 2023 from over 35 countries. These measures impacted approximately $1,217 billion USD in trade worldwide. In the mechanical machinery sector, there were 1,480 TBTs in 2023 from over 60 countries, impacting over $6,000 billion USD in trade.

On the one hand, this regulatory stringency can be a catalyst for greener growth. By setting stricter standards, governments push foreign firms to adopt sustainable practices. Also, firms that comply with these standards may get a competitive edge in markets where green credentials matter.

On the other hand, these measures come with costs. Meeting stricter standards often requires investments in new processes, technologies, and documentation. For large multinationals, this may be manageable. For smaller firms, particularly in low-income countries, compliance can be prohibitive. This creates a tension: regulation intended to promote environmental sustainability ends up excluding producers who lack the capacity to navigate them.

The trade-offs

Environmental trade protection cannot be simply seen as 'good' or 'bad '- it involves trade-offs.

- Sustainability vs competitiveness: Stronger rules can reduce environmental harm but can undermine the ability of smaller firms to compete internationally.

- Transparency vs opacity: TBTs are often difficult to track and operate with little transparency. Numerous, overlapping and complex compliance requirements mean firms may struggle to navigate regulatory requirements, effectively keeping them out of markets with a strong presence of environmental TBTs.

- Regulatory alignment vs divergence: When countries align their standards, trade can flow more easily. Divergent standards, however, multiply compliance costs.

Our research illustrates some of these trade-offs in the UK. For example, before Brexit, the UK chemicals sector benefited from alignment with EU regulation, which reduced uncertainty and facilitated trade. After Brexit, businesses feared divergence with the EU's regulatory regime (REACH). While immediate disruption was less severe than expected, uncertainty about future divergence has weighed heavily on business outlooks.

Why business perceptions matter

Understanding how firms perceive the stringency created by environmental TBT is crucial. How firms interpret and respond to these rules translate into real impact. If companies see standards as predictable and aligned across markets, they may treat them as an incentive to innovate and upgrade. If they see them as fragmented or excessively burdensome, the same standards can generate pessimism, discourage investment and even lead to exit from export markets.

Perceptions also reveal where governments could improve support. Clear guidance and predictable timelines can reduce uncertainty, while dialogue between regulators and firms can prevent rules from becoming unnecessarily costly. Business perceptions shape compliance strategies, competitiveness, and ultimately the effectiveness of environmental trade protection. As environmental concerns become embedded in trade regimes, environmental TBTs will only grow in importance. Their design—and how businesses perceive and respond to them—will determine whether they function as drivers of sustainability or barriers to participation.

Environmental trade protection and business perceptions[1]

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Abstract

Environmental trade protection is being increasingly integrated, through technical measures, in regulatory regimes across countries. The resulting regulatory stringency has a critical influence on business competitiveness, their export capacity, and positioning in global value chains. Yet there is no clear consensus on how businesses perceive these regulations. Using a mixed methods approach, we investigate how business perceptions on the stringency of regulations align with the likely trade effects of environmental regulations in the UK. First, we use secondary data on technical measures for environmental protection and bilateral trade to ascertain regulatory stringency across sectors. Second, we use information from the UK Business perceptions survey to understand overall business attitudes towards the government's approach to regulation for access to international trade opportunities. To focus on the UK chemicals sector, we analyse recent news articles and use semi-structured engagement with business actors to validate sector-specific insights. Our analysis shows the likely sectors in the UK the most exposed to technical measures for environmental protection based on their stringency and the alignment between such stringency and business perceptions. We observe the highest degree of regulatory stringency in chemicals and machinery, with organic chemicals and mechanical machinery most strategic for the UK. Overall, business response to stringency appears to depend largely on export destinations. Triangulating across our findings, we find an expansionary pro-trade effect for the UK from regulatory alignment using data from 2010-2020; however, it becomes clear that with Brexit in 2020, businesses expected a major impediment from the government's plans to transpose EU chemical regulatory system REACH (registration, evaluation, authorization, and restriction of chemicals) into UK law. Yet UK chemical exports performed better than expected in the immediate period following Brexit as regulations remained in-line with EU rules during the implementation period in 2021. However, since then, the risk of regulatory divergence emerged with consequent concerns about higher compliance costs with new data-sharing agreements. As of 2024 and even in 2025, the UK business outlook for the UK chemical industry was substantively pessimistic, with continuing concerns of effects of UK's exit from the EU.

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1. Introduction

Environmental trade protection is increasingly integrated in regulatory regimes across countries through technical measures. As defined by the WTO Agreement of Technical Barriers to Trade (TBTs), these technical measures include regulations laying down product characteristics, their related processes and production methods, administrative provisions, and conformity assessment procedures. Governments have discussed and adopted environmental trade protection measures such as EU's Deforestation Regulation (European Commission 2023) or the US Forest Act (US Congress, 2023).

Under similar regulatory frameworks, governments may notify different measures. The combination of different measures can result in "*regulatory stringency*",[2] in relation to multiple overlapping measures, where the regulations involve several requirements, often difficult to achieve or implement, to be allowed to trade. For example, many steps in production processes, or many certifications, or inspections, or paperwork, etc. Indeed, environmental TBTs are numerous and tend to operate with little transparency, significantly impacting global trade (Santeramo et al. 2025a).

Environmental TBTs can be a catalyst for green growth globally (Huang and Wu, 2022; Dahal and Pandey 2018; Ahmed et al. 2021; Kaufman et al. 2023; WTO 2012; Bai et al., 2023; Falkner and Jaspers, 2012). Despite this potential for environmental trade protection measures to contribute to sustainability efforts, the resulting environmental regulatory stringency creates tensions between environmental goals and the export competitiveness of domestic and foreign firms that need to absorb the costs of navigating and complying with these regulations (Huang and Wu, 2022; Dahal and Pandey 2018; Ahmed et al. 2021; Kaufman et al. 2023; WTO 2012; Bai et al., 2023). Regulatory stringency can have a critical influence on business competitiveness, export capacity, and positioning in global value chains. Business perceptions are an important part of regulatory and policy discussions in different areas of public policy, from innovation and industrial policy to fiscal, labour, and trade policy. Existing studies on trade policy have used business perceptions to understand trade policy uncertainty and identify barriers for firms (Fliess and Busquets, 2006; Cassadei and Iammarino, 2021). However, evidence on how regulatory stringency corresponds with how businesses perceive regulations has focused largely on labour legislation (e.g. Pierre and Scarpetta, 2006; Freeman, 2001; Di Tella and MacCulloch, 2005).

There is little corresponding systematic understanding on how businesses perceive, and therefore respond to, these environmental trade measures. And the precise trade impacts of environmental TBTs are still understudied. These gaps motivate the focus of this study: *How do environmental regulations affecting trade align with business perceptions on the stringency of regulations?* In this paper, we address this research question for 2010-2024 combining different strands of analysis.

First, we begin with an overall understanding on the use of TBTs for environmental protection from 2020-2024. Our analysis shows the likely sectors in the UK the most exposed to technical measures to trade for environmental protection based on their stringency. Until 2020, as an EU Member State, the UK was part of the EU's Customs Union and part of the EU Single Market. Measures notified by the European Commission thus applied also to the UK. Leaving the EU entailed a departure from Customs Union and Single Market. This allowed the UK to set its own regulations for the protection of the environment. Consequently, we find that Brexit implied a change in the type of regulations in the UK - from enforcement measures to technical regulations after Brexit.[3]

Second, we analyse business perceptions in relation to Brexit, from 2020-2024, to understand business attitudes towards the government's approach to regulation for access to international trade

[2] Regulatory stringency is a multifaceted concept - often used in the context of environmental policies and linked to higher carbon costs (e.g., Antoniou et al., 2024) or to outcome-based indicators such as environmental expenditure (Wang et al., 2021), pollution removal rates (Liu et al., 2021), and energy consumption (Yan et al., 2023). In the case of non-tariff measures (NTMs), the presence of multiple overlapping measures targeting the same product can drive regulatory stringency (UNESCAP, 2019).

[3] The UK officially left the EU on 31 January 2020; the implementation period lasted until 31 December 2020; on 1 January 2021, the UK fully exited the EU single market and customs union. In this paper, we use Brexit to refer to 31 January 2020.

opportunities. It also allows us to assess the effort and cost involved in dealing with regulations in relation to international trade. Third, to undertake a more targeted sectoral analysis for UK businesses, we compile news articles from the Nexis database from 2020-2024 to pick changes considering Brexit, with insights from semi-structured engagements with UK business associations as validation.

Finally, we assess the trade effects for UK exports in relation to the environmental TBTs notified and implemented by trading partners over a shorter period prior to Brexit 2010-2020.[4] The analysis shows that overall, the UK did not consistently export more to notifying countries, and importing countries did not notify more measures on major importing sectors. However, disaggregating these effects across sectors, a marked heterogeneity appears in terms of volumes of trade toward notifying countries.

Overall, the mixed methods approach allows us to understand business perceptions on regulatory stringency in the UK and corresponding links with international trade. We look at environmental regulations affecting UK trade and how these align with business perceptions on the stringency of regulations. While we begin by looking at perceptions generally to regulations in relation to trade, our analysis focuses on the chemicals sector which we draw as being of strategic importance to the UK from a regulatory perspective on international trade but also one where Brexit has affected the trajectory of UK businesses and how they have responded to environmental TBTs.

Interestingly, we find a positive response from UKs chemical businesses to environmental regulations using our empirical analysis over 2010-2020, arguably, capturing the pro-trade effect from regulatory alignment between the UK and the main destinations for its exports. However, with Brexit in 2020, our sectoral analysis suggests that businesses expected major impediments from the government's plans to transpose EU chemical regulatory system REACH (registration, evaluation, authorization, and restriction of chemicals) into UK law. Contrary to expectations, UK chemical exports performed better than expected during the Brexit implementation period (over 2020) as regulations remained in-line with EU rules. However, the risk of regulatory divergence emerged soon after with consequent concerns about higher compliance costs with new data-sharing agreements. As of 2024 and 2025, the UK business outlook for the UK chemical industry was substantively pessimistic, with continuing concerns of effects of UK's exit from the EU. As differences in environmental TBTs are perceived as detrimental for trade, there is a case for the UK to continue to align to EU regulations with the alternative being the freedom to regulate perhaps in ways aligning more with other major trading partners (e.g. US, Canada, etc.).

Our study is interdisciplinary combining insights from trade economics and political economy analysis of the role played by businesses. We highlight our contribution to this literature and fill in gaps on environmental trade regulations and the role of business (Grossman and Helpman, 1994; Saha, 2019; Saha, 2020; Saha et al. 2023: Santeramo et al., 2025a). The remainder of the paper is structured as follows. Section 2 outlines the background and relevant literature on environmental trade protection and business perceptions. Section 3 describes the analysis of environmental TBTs and presents stylised facts for the full period of analysis from 2010-2024. Section 4 analyses business perceptions using the UK business perception surveys and focuses on the chemicals sector using news articles and semi-structured stakeholder engagements. Section 5 outlines the results for the trade effects for the earlier period from 2010-2020. Section 5 discusses the key messages and provides concluding remarks.

[4] We are not able to account for a Brexit effect in our empirical analysis due to data availability at the time of writing this paper, but we draw inferences on businesses expecting effects as a result.

2. Background and relevant literature

2.1. Environmental Trade protection

Environmental provisions can be expected to promote trade flows by pushing firms to develop more environmentally friendly technologies, thereby prompting innovations that compensate or even surpass the costs of complying with new regulations (Porter,1991; Porter and van der Linde, 1995; Brandi et al., 2019). While environmental TBTs may have a positive effect on trade in environmental goods, trade in Low-Middle Income Countries (LMICs) tends to be adversely affected as their firms (as well as small firms in high-income countries) may not yet have the capabilities to compete in environmental goods markets and consequently find it difficult to adapt to a new and more stringent regulatory regimes (De Melo and Solleder, 2020).

At the same time, the literature consistently finds that regulatory heterogeneity has negative effects on trade flows (Franssen and Solleder, 2016; Korwatanasakul and Baek, 2021; Inui et al., 2021; Lombini, 2021), whereas convergence and cooperation tend to stimulate trade flows (Grossman et al., 2021; Santeramo and Lamonaca, 2022; Ghodsi, 2024; Acquah et al. 2024). The rationale being that greater regulatory divergence increases trade costs, as firms must identify foreign regulatory requirements, adapt their products and production processes, and demonstrate compliance in multiple markets. If regulations vary across export destinations, compliance costs increase with the number of target markets (Blyde and Ramírez, 2024). According to Lamy (2015, 2016), firms facing different regulations across multiple markets must produce different product versions, often at a significant cost due to reduced economies of scale[5].

Such regulatory heterogeneity has been measured by different indicators such as intensity, coverage, and structure (Di Ubaldo et al. 2025; Garcés and Vogt, 2025; Cadot and Malouche, 2012; Gourdon, 2014; UNCTAD, 2017). Among these, intensity assumes that (i) a greater number of measures increases the likelihood of achieving policy objectives (e.g., environmental protection); (ii) each additional measure raises regulatory compliance costs for firms; (iii) for quality-related technical measures, a higher number of regulations constrains firms' endogenous quality choices, influencing market participation-especially for low-quality and low-productivity firms (e.g., Disdier et al., 2023). Consequently, intensity can be proxied by the number of imposed measures or specified through actual regulatory requirements that may translate into higher stringency.

Regulatory stringency can have a critical influence on business competitiveness, and the precise trade impacts of environmental TBTs remain understudied with little corresponding systematic understanding on how businesses perceive these environmental trade measures.

2.2. Business perceptions of environmental regulations[6]

Early work linking business perceptions of environmental regulations and their effects on trade was motivated by the advent of international agreements on environmental protection. Perhaps the most iconic example is the Montreal Protocol, an unprecedented international agreement enforced in 1989 to regulate the use of ozone depleting substances (chlorofluorocarbons CFCs) and widely regarded as successful in phasing out these harmful substances (Luken and Grof, 2006; Gonzalez et al. 2015).

In the context of the Montreal Protocol (and subsequent EU regulations of ozone depleting chemicals), Purvis et al. (1997) studied perceptions of UK firms to understand the challenges they faced and how they adapted to such regulations and found that small firms were particularly affected, facing numerous uncertainties on how to respond and absorb the costs of adopting new technologies, while market power tended to concentrate on larger firms. Purvis et al. (1997) early on noted that businesses generally

[5] The novel dataset on technical measures for environmental protection (namely, "*A Global Environmental Non-tariff measures Database*" - END) proves useful to analyze the extent of regulatory convergence or divergence in environmental trade protection though regulatory measures (Santeramo et al., 2025b).

[6] See Appendix Table A1 for a summary of literature reviewed for this study.

disliked the idea of strict enforcements and rapid phaseouts and favoured more flexible regulations that allowed them time to adapt.

Business perceptions can reveal underlying views and motivations of business representatives that influence their behaviour and response to environmental regulations. Research on business perceptions and regulations policy has been generally concerned with measuring the extent and effects of regulatory or policy (in)effectiveness, stringency, and uncertainty on business behaviour and competitiveness. For example, Cassadei and Iammarino (2021) used business perceptions to understand trade policy uncertainty surrounding Brexit and how it affected textile firms in the UK using a survey with 688 firms for 2019-2020, and found that firms' perceived effects of the trade policy uncertainty caused by Brexit varied depending on factors related to position in global value chains, production, and integration. Arguably, in this case, business perceptions were driven by the risk of diverging from regulatory alignment (Baldock and Nicholson, 2022; Jones and Burns, 2024) – similarities in regulatory requirements between the UK and the main destinations for its exports.

In an OECD report, Fliess and Busquets (2006) also used a series of business perception surveys from a range of countries, compiled by government ministries and consultancies, to identify trade policy barriers for SMEs. Other studies have also looked at how business perceptions matched specific regulations. For example, Pierre and Scarpetta (2006) assessed labour regulatory stringency and how this stringency affected business operations using the Worlds Bank's 'Doing Business' dataset on laws and regulations and the World Bank's 'Investment Climate Surveys'. Quite a few studies find that firm's perceptions can be closely associated to the actual stringency of regulations (Pierre and Scarpetta, 2006; Fliess and Busquets, 2006).

Several studies have used business perceptions to understand the barriers and opportunities that certain regulations pose for business innovation (Kidd et al., 2021; Ortiz and Fernandez, 2022; De Fuentes et al., 2020; Jiang et al., 2024). These studies have investigated business concerns and barriers to new technology (Kidd et al., 2021), business' perceptions on innovation barriers (Ortiz and Fernandez, 2022) and the extent to which Montreal Protocol stimulated environmental innovations (Digoua, 2021). However, these studies are not always clear on whether there are differences in business response based on firm capabilities. A change in business perceptions would be accompanied by responses to navigate new expected regulatory burdens – arguably, sector and destination specific and that can be influenced by timely and systematic information and guidance on the regulations. The extensive literature on state-business relations also emphasizes the importance of opening information channels between businesses and governments for policy/regulatory formulation, implying the relevance of understanding business perceptions (Evans 1995, Rodrik 2009, Saha et al., 2019; Lim et al., 2021).

At the same time, some studies have cautioned that business perceptions may be misleading for policy given the multiple motives influencing views and perceptions (Kaplan and Pathania, 2010; Peck et al. 2012). Misch et al. (2014) exemplified this in the case of fiscal policy, showing that firm perception surveys usually favour fiscal incentives which are not necessarily conducive to growth.

Dechezleprêtre and Sato (2014)'s review of studies on the environmental regulation – trade nexus suggests a positive response from businesses (in general) to environmental regulations, as they find though environmental regulations do impose a cost, their benefit vastly outweigh the costs. For example, there being ample evidence of environmental regulations inducing innovation in low-carbon technologies, while discouraging developments in carbon-intensive technologies. Similarly, Sauvage (2014) used the Environmental Policy Stringency (EPS) index and concluded that a higher level of environmental regulatory stringency was associated with more green trade among OECD countries. On the other hand, studies (for example, Dahal and Pandey, 2018 in the case of Southeast Asia) argue that environmental restrictions on trade, from both the EU and North America, negatively impact businesses' competitiveness with low capacity to compete in environmental goods markets.

Kellenberg (2009) and Wagner and Timmins (2008) took a different approach; they used business perceptions (from the World Economic Forum's perceptions survey) to create a cross-national measure

of environmental regulatory stringency. Both studies found evidence supporting the "pollution haven effect", linking lower levels of environmental regulatory stringency to growth in foreign direct investment (FDI).

Lastly, a report by the U.S International Trade Commission (2014) used a series of roundtables, hearings, and written requests across several business sectors to understand the trade barriers that U.S. based SMEs faced with regards to EU regulations. Although this report surveyed a wide range of regulations, many of them were related to the EU's use of environmental TBTs. The report covered exporting SMEs in agriculture (dried fruits, animal feed, cheese, wheat, corn, nuts, and meat), manufacturing (machinery, electronics, transportation equipment, other miscellaneous), chemicals and apparel (pharmaceuticals, plastics, cosmetics, denim), and services (professional, scientific, technical). The report found that SMEs perceive EU regulations, including environmental, as putting them on a disadvantage with regards to larger enterprises. The negative perceptions stem from the highest costs related to the approval process of products regardless of the quantities exported. Large firms are able to reduce these costs by exporting larger amounts of products. Other important barriers related to environmental regulations included lack of regulatory transparency, differences in how the US and EU measure environmental requirements, and the high costs of tracking all material inputs (as required by some environmental regulations in the EU).

More specifically, the USITC (2014) study shows that US chemical firms reported the EU's chemical regulatory system REACH (registration, evaluation, authorization, and restriction of chemicals) to be a significant barrier. The obstacles were attributable to the cost and time required, complex testing, and information requirements about products. The study also refers to a specific regulation on the marketing and use of biocides as affecting US exports significantly. The manufacturing firms reported to facing barriers mostly related to safety certifications and complexities in the VAT. Agriculture and food SMEs reported facing particular high costs of non-tariff measures, which are the highest in any industry. The approval of GM traits was a particular challenge together with the rapidly changing regulatory requirements.

In the UK, several surveys exist measuring business perceptions of regulatory burdens aiming to shed light on how to improve the country's regulatory environment and make it easier for businesses to navigate and comply with it (e.g., BEIS, 2020). The UK government's Better Regulation Executive unit compiles business perceptions, through surveys and interviews, to understand regulatory burdens and improve their efficiency (BEIS, 2019).

Despite a body of evidence on environmental regulations generally, and the existing of regulations related UK surveys, there is little corresponding systematic understanding on how UK businesses perceive environmental trade measures and sector-specific responses to changes remains understudied. This study responds to these gaps and brings together different strands of evidence to conduct a mixed methods analysis of business perceptions on the stringency of regulations in the UK and related trade effects.

3. Environmental TBTs

4.1. Technical measures

Technical measures are regulations and conformity assessment procedures notified under the WTO Agreement of Technical Barriers to Trade (TBTs), and as defined by the Annex I of the Agreement. Technical regulations lay down product characteristics, their related processes and production methods, and administrative provisions.

The United Nations Conference on Trade and Development developed a taxonomy of non-tariff measures (UNCTAD, 2019). It groups notifications resulting from the enforcement of a technical measure (i.e., administrative provisions) under class B1. Notifications under classes B2 (i.e., tolerance limits for residues and restricted use of substances), B3 (i.e., labelling, marking and packaging

requirements), B6 (i.e., product identity requirements), and B7 (i.e., product quality, safety or performance requirements) are technical regulations on product characteristics. The class B4 collects notifications on production or post-production requirements. Conformity assessment procedures are practices used, directly or indirectly, to determine that relevant requirements in technical regulations or standards are fulfilled. They are grouped under class B8. Complying with requirements set by technical measures is mandatory. The class B9 used for TBTs not elsewhere specified.

We gather data on regular notifications for the protection of the environment from the Global Environmental Non-tariff measures Database (END), that groups technical measures according to the classification of requirements provided by UNCTAD (2019). We extend the set of information provided by the original source of data with details on product coverage and type of requirements[7]. The steps of this analysis are summarised below.

We begin with data on TBT notifications in the END repository. Each notification is associated with a summary document (for example: G/TBT/N/EU/530). From this document, we know the notification date (top on the left: 5 January 2018, in the example); the country notifying the measure (point 1: the EU in the example); the products covered (point 4) and a short description of the measure (point 6) and the objective of the measure (point 7: Protection of public health and of the environment, in the example). For products covered, only one-third of measures have products with HS codes; in the remaining cases we have a product description (such as in the example). We screened all the measures without HS codes and attributed the codes (using https://www.wcotradetools.org/en/harmonized-system) on the basis of the description provided in the document. The more specific the description, the more disaggregated the code we were able to attribute.[8] For description of the measure, we screened the description of all environmental TBTs to classify their requirements according to the taxonomy provided by UNCTAD (2019).[9] The example refers to requirements on the use of substances, therefore we classified this measure under the class B2.

A TBT may affect products (6-digit of the Harmonised System, HS), categories (HS 4-digit), or sectors (HS 2-digit). Where missing, we identify the 2-digit codes of HS sectors affected by each measure.[10] This allows us to expand the set of information on environmental TBTs for the empirical analysis. We aggregate information on trade flows and environmental TBTs with HS codes at the HS 2-digit level to ensure compatibility across different data sources and notifications. We match notifications data with UK exports, sourced from the *Base pour l'Analyse du Commerce International* (BACI) of the *Centre d'Études Prospectives et d'Informations Internationales* (CEPII). The period between 2010 and 2020 is common to all sources of data.

WTO members have notified technical measures for the protection of the environment since 2010s. The European Union (EU) is a key partner of the UK, and in 2022, UK exported goods for 227 billion USD (50 percent of its traded values) to the EU. Both EU Member States and the European Commission notify TBTs. We attribute notifications by single Member States only to the notifying country and notifications by the European Commission to all Member States. The final dataset includes information for 155 UK

[7] Our dataset builds on the END repository including specific information for measures that are relevant for UK industries. The dataset is available at https://globalgovernanceprogramme.eui.eu/project/a-global-environmental-non-tariff-measures-database/

[88] Where there were doubts, we consulted experts: this is the case of the example -biocidal products (common for EU notifications)-. Where we classified biocidal products in HS28, HS29, HS38 based on discussions with microbiologists.

[9] https://unctad.org/system/files/official-document/ditctab2019d5_en.pdf

[10] Only 33 percent of environmental TBTs include HS codes, either 2-digit, or 4-digit, or 6-digit depending on the coverage of the technical measure. The official document of notifications provides a qualitative description of the products covered, joint with codes of the Customs Cooperation Council Nomenclature (CCCN), otherwise national tariff heading, and International Classification for Standards (ICS) numbers (where applicable). We conduct a text analysis on this information to attribute HS codes where missing.

trading partners (68 percent are notifying countries) and 96 sectors defined at the HS 2-digit level (95 percent are covered by at least one environmental TBT) from 2010 to 2020. [11]

We find that global environmental regulations are concentrated in a few high-valued sectors, observable in **Table 1** that presents the number (column 1) and the cumulative share (column 2) of technical measures for the protection of the environment that apply at the HS 2-digit level as of 2023-2024. These, joint with data on the number of notifying countries (column 3), provide an indication of the degree of regulatory stringency at the sector level worldwide. The top ten regulated sectors cover 71 percent of total environmental TBTs and accounted for about 14,000 billion USD of traded value in 2022 (column 4).

Table 1. Top 10 regulated sectors globally in 2023

HS2		Env-TBTs (2023)		Notifying countries	Trade (2022)
Code	Description	nbr. (1)	cum. % (2)	nbr. (3)	bln USD (4)
84	Mechanical machinery	766	12	62	2,554
38	Miscellaneous chemicals	737	24	49	320
85	Electrical machinery	714	36	68	3,496
29	Organic chemicals	609	45	36	541
28	Inorganic chemicals	590	55	39	213
87	Vehicles	314	60	51	1,608
27	Mineral fuels	189	63	53	3,819
31	Fertilisers	175	66	27	143
39	Plastics	170	69	55	798
73	Iron and steel products	126	71	41	390

Source: Author's own.

We observe the highest degree of regulatory stringency for chemicals and machinery. Chemicals have a total of 2,111 TBTs in miscellaneous chemicals including pesticides (HS 38), organic and inorganic compounds (HS 29 and HS 28), and fertilisers (HS 31). The notification process in the chemical industry appears to be the prerogative of a small group of WTO members (an average, there are about 37 notifying countries per HS 2-digit sector). The regulatory intensity of machinery ranges from 766 measure in the mechanical sector (HS 84) and 714 in electrical (HS 85), notified by numerous WTO members (68 for HS 85 and 62 for H S84). These patterns for machinery highlight the global relevance of an industry that valued more than 6,000 billion USD in 2022.

4.3. UK's strategic sectors

We find that among the sectors where the UK is notifying, and within chemicals and machinery with the highest degree of regulatory stringency, organic chemicals and mechanical machinery appear to be strategic for the UK with most notifications. Brexit in 2020 appears to have implied a change in the type of regulations in chemicals and machinery for the UK. From enforcement measures that were notified before Brexit to more technical regulations (73 percent) were notified post-Brexit. The most adopted technical regulations relate to tolerance limits for residues and restricted use of substances (class B2) in the chemical sector and product quality, safety or performance requirement (class B7) in the machinery sector. UK notifications on environmental TBTs for chemicals (**Box 1**) overall doubled post-Brexit, from about 7 notifications pre-Brexit (first notified in 2017) to 15 post-Brexit (last notified in 2023).[12]

Box 1. UK notifications Pre- and Post-Brexit

Pre-Brexit (before 2020)	Post-Brexit (after 2020)
7 environmental TBTs:	**15 environmental TBTs:**

[11] In **Table S.4.** in the Appendix, environmental TBTs at the sector level, you can find the number and share of TBT notifications per 2-digit in 2023. There is the world total and details for major countries (EU, US, CHN) and for UK.
[12] Details are in the Appendix (Table S.1 (Box S.1 and Table S.1).

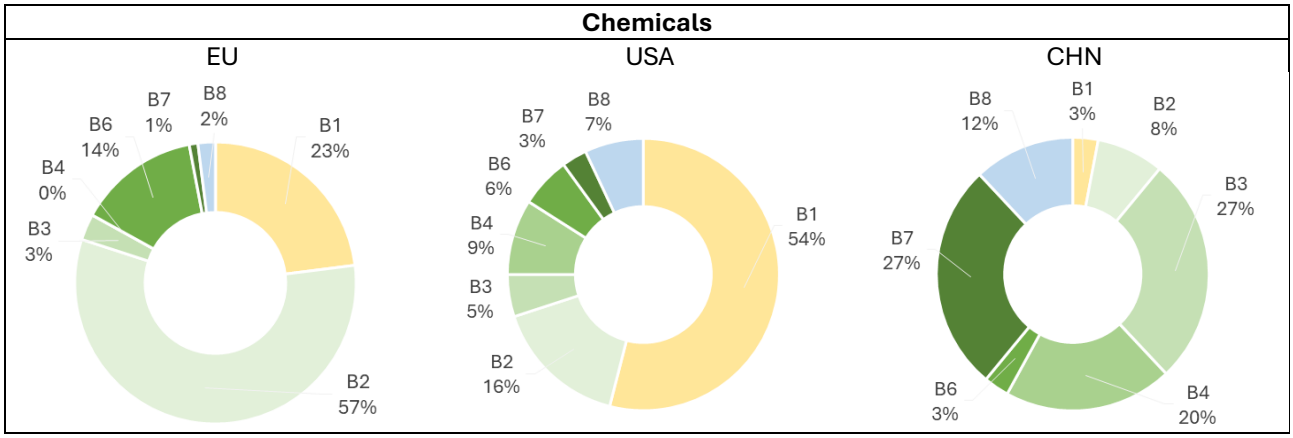
▪ first notified in 2017 ▪ 7 enforcement: - 7 import authorisation/licensing (B1) ▪ 1 technical regulation - 1 product identity requirements (B6)	▪ last notified in 2023 ▪ 3 enforcement: - 3 import authorisation/licensing (B1) ▪ 11 technical regulations - 4 tolerance limits for residues and restricted use of substances (B2) - 3 labelling, marking and packaging requirements (B3) - 4 product quality, safety or performance requirement (B7) ▪ 2 conformity assessment procedures - 2 conformity assessment (B8)

Source: Author's own.

Particularly, after Brexit in 2020, the UK regulates the chemical and machinery industries (see columns 5 and 6 in **Table 2**). While 40% of notifications are for chemicals, about one-third of post-Brexit notifications cover the machinery industry (**Table S.1** in the Appendix). Looking at the patterns for the top 10 exporting sectors and partners for the UK in **Table 3**, we see that the EU and the US are the top notifying countries (column 4) and top UK partners (column 3) for organic chemicals (HS 29) and for mechanical machinery (HS 84). The role of China stands out as for mechanical machinery as the second top notifying country after the US. For the EU, the United States (US) and China, there is a similarly upward trend in these sectoral notifications. For example, for the EU for chemicals (see columns 1 to 3 in Table 2), and the US and China for machinery (see columns 7-8 and 10-11 in Table 2). These patterns suggest a potential adjustment strategy of the UK with respect to these major players.

Next, we focus on the chemicals sector for the UK as the most strategic sector for environmental TBTs in terms of regulatory stringency. Looking at the general landscape of types of environmental TBTs in chemicals, environmental regulations in this sector would seem to differ depending on the WTO members. We consider three major players for the UK i.e., the EU, the US, and China (**Figure 1)**.

Figure 1. Types of environmental TBTs notified by major players



Source: Author's own.

Notes: Acronyms are enforcement (ENF), technical regulation (TEC), conformity assessment procedure (CAP). UNCTAD classes are import authorisation/licensing (B1), tolerance limits for residues and restricted use of substances (B2), labelling, marking and packaging requirements (B3), production or post-production requirements (B4), product identity requirements (B6), product quality, safety or performance requirements (B7), conformity assessment (B8).

For chemicals, the US relies on enforcement measures[13] (54 percent), whereas the EU and China mostly adopt technical regulations (75 percent and 85 percent, respectively). However, the type of

[13] Authorisation or licensing requirements established to enforce technical regulations or conformity-assessment procedures (UNCTAD, 2019). These are generally associated with tolerance limits for residues and restricted use of substances, requirements frequently used by the EU (not as often in China). Examples for the US include the prohibition (i.e., zero-tolerance

requirements is different: the EU is more concerned with tolerance limits for residues and restricted use of substances (class B2, 57 percent); China indiscriminately uses labelling, marking and packaging requirements (class B3, 27 percent) and product quality, safety or performance requirements (class B7, 27 percent). UKs environmental TBTs (**Table 2** and **Table S.2.** in the Appendix) shows that among the top ten regulated sectors globally, the UK notifies in most of them, except for mineral fuels (HS 27), fertilisers (HS 31), and iron and steel products (HS 73).

Following Brexit, the UK largely replicated EU legislative frameworks, ensuring continuity in regulatory standards across various sectors. This strategy was particularly evident in the chemical sector, where the EU REACH Regulation was transposed into UK law on 1 January 2021, becoming UK REACH.[14] Both UK REACH and EU REACH now function independently, requiring businesses to comply with both regulations where necessary. While the UK has largely retained and adapted EU regulatory frameworks, it has also introduced domestic policies in areas such as plastic pollution reduction and electric vehicle infrastructure.

In May 2024, the UK notified the WTO (G/TBT/N/GBR/89) of a government consultation proposing amendments to the transitional provisions for UK REACH – that included an Alternative Transitional Registration Model (ATRm), aimed at maintaining human health and environmental protections while reducing compliance costs for businesses transitioning from EU REACH to UK REACH.[15] Similarly, the EU Classification, Labelling, and Packaging (CLP) Regulation (EC No 1272/2008), which aligns chemical classification systems with the United Nations' Globally Harmonized System (GHS), was retained in GB law post-Brexit.[16] The UK also retained Regulation (EC) No 1107/2009 concerning plant protection products, notifying changes in authorisations for active substances, such as alpha-cypermethrin (G/TBT/N/GBR/54), mancozeb (G/TBT/N/GBR/70), famoxadone (G/TBT/N/GBR/75), and indoxacarb (G/TBT/N/GBR/74).

Many hazardous substances continue to be regulated under EU-aligned frameworks, even when incorporated into other goods; for instance, the UK has maintained restrictions on hazardous substances in electrical and electronic equipment (RoHS Regulations), originally introduced under EU Directive 2011/65/EU.[17] In the plastics sector, the UK implemented market restrictions on problematic single-use plastic (SUP) items (G/TBT/N/GBR/41) in 2021, aligning with Article 5 of the EU Single-Use Plastics Directive (EU 2019/904); however, the UK has also pursued independent domestic initiatives in this sector.[18] Further examples of UK-specific initiatives include the Automated and Electric Vehicles (AEV) Act 2018, which grants the UK government powers to introduce secondary legislation. In 2021, this led to mandating smart functionality in private electric vehicle charge points (G/TBT/N/GBR/38, G/TBT/N/GBR/40), ensuring higher energy efficiency and interoperability.

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limit) of trichloroethylene (G/TBT/N/USA/1270 and G/TBT/N/USA/2062), methylene chloride and N-methylpyrrolidone (G/TBT/N/USA/1271), mercury in certain items (G/TBT/N/USA/430 and G/TBT/N/USA/632).

[14] governing many chemical substances manufactured in or imported into Great Britain (GB – England, Scotland, Wales), while under the Northern Ireland Protocol, EU REACH remains in force in Northern Ireland. Although UK REACH mirrors its EU counterpart, modifications were made to ensure its operability within a domestic regulatory framework.

[15] The consultation also explored streamlining restrictions and reporting requirements, allowing faster decisions on hazardous substances and reducing redundant documentation burdens.

[16] While Great Britain continues to adopt GHS independently from the EU, amendments were necessary to ensure the effective functioning of GB CLP. This led to several TBT notifications, including the GB Mandatory Classification and Labelling (MCL) List (G/TBT/N/GBR/58) and subsequent updates on hazardous substances in 2023 (G/TBT/N/GBR/60, G/TBT/N/GBR/67) and 2024 (G/TBT/N/GBR/78).

[17] This framework has generated several UK TBT notifications, including those in 2021 (G/TBT/N/GBR/43), 2022 (G/TBT/N/GBR/46), and 2023 (G/TBT/N/GBR/56).

[18] A key focus has been reducing plastic pollution and transitioning towards a circular economy, emphasising the principles of Reduce, Reuse, Recycle. One example is the UK's regulatory push to phase out wet wipes containing plastic, which are a major source of microplastic pollution. The UK government (G/TBT/N/GBR/84), along with devolved administrations in Scotland (G/TBT/N/GBR/92), Northern Ireland (G/TBT/N/GBR/94), and Wales (G/TBT/N/GBR/100), has proposed regulations aimed at reducing microplastic contamination in water systems and food chains.

The divergence between UK and EU regulations gradually emerged, particularly as the UK government explored independent regulatory approaches, such as the Alternative Transitional Registration Model (ATRm) under UK REACH. As regulatory divergence continues to unfold, businesses and policymakers are navigating dual compliance requirements, needing to assess the evolving implications of UK-specific technical regulations on trade and environmental governance.

Table 2. Environmental TBTs notified by the UK: A comparison with major players

				EU				UK		USA			CHN		
				2010	2019	2023		2019	2023	2010	2023		2010	2023	
HS section	HS description	HS 2-digit	Description	nbr. (1)	nbr. (2)	nbr. (3)	% (4)	nbr. (5)	nbr. (6)	nbr. (7)	nbr. (8)	% (9)	nbr. (10)	nbr. (11)	% (12)
VI	Chemicals	28	Inorganic chemicals	20	196	263	24.2		3	10	182	20.0		8	2.2
		29	Organic chemicals	18	197	263	24.2		3	9	187	20.6		8	2.2
		33	Cosmetics		1	3	0.3	4	4						
		36	Explosives						1	1	4	0.4			
		38	Miscellaneous chemicals	26	249	348	32.0		5	4	98	10.8	12	35	9.8
VII	Plastics	39	Plastics		2	4	0.4	1	4		6	0.7		3	0.8
		40	Rubber		1	1	0.1		1	1	2	0.2	1	4	1.1
XVI	Machinery	84	Mechanical machinery	10	33	36	3.3		2	26	160	17.6	5	73	20.5
		85	Electrical machinery	7	39	65	6.0		4	19	101	11.1	10	49	13.8
XVII	Vehicles	87	Vehicles	2	22	27	2.5	1	4	11	55	6.1	3	29	8.1
XVIII	Instruments	90	Optical instruments		3	4	0.4		2		3	0.3		6	1.7
XX	Miscellaneous	94	Furniture						1	3	10	1.1		7	2.0
			Other	5	40	75	6.9			13	101	11.1	8	134	37.6

Source: Author's own.

Table 3. Top 10 exporting sectors and partners for the UK

HS2		UK exports (Billion USD)		Top 3 UK partners (2018)			Top 3 notifying countries (2023)		
Code	Description	2018 (1)	2022 (2)	bln USD (3)			nbr env-TBTs (4)		
84	Mechanical machinery	65.6	71.7	EU 25.8	USA 9.8	SGP 3.1	USA 160	CHN 73	SAU 45
87	Vehicles	57	40	EU 24.9	USA 11.0	CHN 5.8	USA 55	CHN 29	EU 27
71	Precious	45.4	49.1	CHE 19.3	CHN 6.1	EU 4.5	CHN 3	ECU 2	EU 1
27	Mineral fuels	44.7	64.5	EU 27.9	CHN 4.8	USA 4.2	USA 20	CHN 12	UGA 16
85	Electrical machinery	27.9	25.7	EU 15.6	USA 3.0	CHN 1.0	USA 101	EU 65	SAU 58
30	Pharmaceuticals	26.3	27.3	EU 12.5	USA 4.8	CHN 1.4	CAN 2	CUB 2	RWA 2
90	Optical instruments	17.8	18.9	EU 7.1	USA 3.5	CHN 1.2	KWT 11	CHN 6	IND 6
88	Aircraft	14.3	12.7	EU 7.2	USA 2.1	CAN 0.8	USA 4	JPN 1	MEX 1
29	Organic chemicals	13.3	12.2	EU 5.6	USA 2.6	CHE 2.5	EU 263	USA 187	IND 30
39	Plastics	12.2	12.4	EU 8.1	USA 0.9	CHN 0.4	UGA 24	RWA 10	SAU 8

Source: Author's own.

3. Business perceptions

Next, we analyse UK business attitudes to trade related regulations since Brexit in 2020-2024. First, we use the UK business perceptions surveys to understand overall business attitudes towards regulations in relation to international trade. Second, to focus on the chemicals sector in the UK, we compile 506 news articles from the Nexis database.

4.1. UK business perceptions on regulations

The UK business perception surveys allow us to capture relevant patterns in UK business attitudes to trade related regulations, including challenges of compliance. The UK business perceptions surveys (2020-2024) give an overall picture of business attitudes towards trade related regulations and the effort and cost involved in dealing with regulations. These surveys ask UK businesses for the (perceived) causes of regulatory burden, the impact and response to such burden, the perception on the regulators themselves and how changes in regulations affect those perceptions, and different aspects of the communication between firms and regulators (for instance, the communication of regulatory changes is effective). The surveys are based on telephone interviews with a random sample of private sector UK businesses, with selection based on size, sector and country, weighted to business population estimates such that the data is representative by these criteria.

The UK Business perceptions surveys show that business attitudes mirror their experience in trying to meet the regulatory requirements – businesses reporting greater time taken for complying to regulations for access to international trade opportunities also perceived regulations as an obstacle to success. Exporting businesses show markedly worse sentiment about trade regulation than the average firm. The 2022 and 2024 surveys report that compared to 2020, "*perceptions about the government's approach to regulation were less positive*". Businesses sought clarity on purpose of regulation and reported greater difficulties in achieving compliance with regulations.

The evidence in relation to Brexit specifically shows a substantial and worsening burden. EU exit was already the dominant concern in business perceptions of regulation well before the transition period ended. By 2022, 28% of businesses found EU exit regulatory changes challenging to comply with; by 2024, 41% found the post-exit regulatory arrangements more challenging than what preceded them. Businesses cited various reasons for this worsening burden - operational problems including staffing issues (44%), considerable financial costs (33%), time commitments (25%), keeping up with changes to the regulation or guidance (17%), and reduced business activity (13%).

Sector breakdowns show these patterns most concentrated in the most trade-exposed sectors – in Manufacturing, Retail and Distribution and Transport and Storage. Businesses in these sectors also report significantly more difficulty with trade-related and EU exit regulation than other sectors, while showing no significant difference from average on general regulatory burden.

For 2024, the survey shows that businesses for whom environmental rules are relevant are significantly more likely to see regulation overall as an obstacle to business success. 75% of businesses reported environmental rules were a relevant regulatory area, and among these 47% found environmental rules challenging to comply with. Environmental rules are therefore a strong predictor of seeing regulations as an obstacle to business success.

Overall, the change in business perceptions to regulations suggest an alignment with the increase in regulatory stringency for the manufacturing sector in the UK. As UK firms prepared to navigate the new expected regulatory burdens in the aftermath of Brexit, their perceptions mirrored the likely additional burden of compliance from 2020. However, this would also depend on the sector and destination markets for UK firms. It is clear at an aggregate level, UK business perceptions on stringency are more driven by a lack of information and guidance on the regulations.

4.2. UK Chemicals sector

The UK business surveys do not allow us to isolate perceptions for the chemicals sector. To focus on the chemicals sector as the most strategic sector for environmental TBTs for the UK, we conduct a targeted thematic review of news articles compiled from the Nexis database for the period 01 Jan, 2020 to 01 Dec, 2024. The articles were narrowed by using the basic terms *'UK', 'business', 'chemicals', 'technical trade barriers'* to appear together – these keyword searches helped identify reporting relevant to chemical exports, environmental regulation and technical barriers to trade. Our search and filtering process gave us 506 news articles that were organised using five themes: export trends and disruptions; export barriers; differences between UK and EU regulation; firms' compliance capabilities; and business perceptions and responses. The synthesis then compared key issues that emerged from the data analysis with TBTs with developments across the themes using text analysis. Three key areas were used to group the text analysis (patterns; changes; reported challenges) across the news articles. In addition, insights from semi-structured engagements with UK business associations were used to validate the analysis of sector-specific insights.[19]

Overall, we find that post-Brexit pressures on UK chemical firms arise principally from regulatory duplication and uncertainty. While existing experience of EU requirements provided a basis for compliance, it did not eliminate the uncertainty due to additional costs of operating across separate regulatory systems. We report five main findings from this research that we triangulate with the survey analysis on business perspectives.

First, the pattern that emerges clearly from the news articles is that businesses expected a major impediment from the government's plans to transpose EU REACH into UK law (UK REACH came into effect in 2021) – with increase in compliance costs and consequent weakening of competitiveness being reported for UK firms. EU has been a major partner for the UK chemicals industry indicating substantive exposure to changes in the trading relationship. The analysis of news articles suggests discussions of month-on-month fall in chemical exports to the EU as of January 2021. We found that the articles extensively report on a survey with 38 key chemical UK businesses in 2019 (CBA, 2019) revealed that "*three-quarters of companies do not own the testing data for registrations they currently hold under the EU REACH*". In 2019, the UK's chemical industry trade association said that "*it feared regulatory costs of up to 500m if there was no free trade agreement post-Brexit. This is similar to the amount the industry spent during last 10 years to comply with EU's REACH"*.

Second, and importantly, we found that UK chemical businesses respond differently depending on the different destinations for their exports. More so, while being driven by exporting UK businesses, there were reported differences by businesses that were reliant on specific export destinations. For instance, while EU REACH takes a precautionary approach to chemical risk such that "*a chemical is considered hazardous until proven safe"*, the US has an alternative approach to regulation, assuming "*a chemical is safe until proven otherwise*" (Bradford, 2020). We find that there were reported changes in business strategies as a result especially for UK firms reliant on the EU market.

Third, chemical exports performed better than expected immediately post-Brexit in 2020, despite being expected to be significantly impacted. This is mostly because "*regulations relevant to chemicals*

[19] While our initial approach was designed as roundtables with businesses, we adapted this to the sensitivities of our research agenda – the use of news articles allows us to obtain more objective insights on business activities, and we validate the analysis of these articles through semi-structured engagements with business associations. These engagements consisted of a series of discussions with key trade personnel of two major industry associations in the UK. We thank the industry bodies for their time in responding to our queries while acknowledging their request to remain anonymous. Semi-structured engagements were driven by a discussion guide structured using the analysis across the three areas of the news analysis, exploring the salience of identified themes. While specific topics were used to structure the discussions, we adopted an approach where the respondents led the discussions. The findings were triangulated comparing stakeholder accounts with the findings from new articles, identifying convergence across our themes.

remained in-line with EU rules" (Brexit and Covid make for perfect storm during a tumultuous year, 2021). Chemical exports were subsequently reported to be marginally above their 2019 level by the end of 2021. For the most part, the UK had not made any major changes to chemical regulations in the immediate implementation period.

Fourth, it was being reported that over time regulatory divergence was likely "*because UK REACH need not follow developments in the EU*" (UK in a Changing Europe, 2021). Consequently, it was reported that "*such divergence risks trade and market access for chemical goods*". As of 2024, we found that the business outlook for chemicals was pessimistic, with the view that the UK had failed to "*develop a cost-effective regulatory regime to replace the EU system of chemicals registration*" and 40% of UK chemical output is directly affected by the UK's exit from the EU. (United Kingdom Petrochemicals: Key View; 2024).

Finally, a major challenge which appears magnified for UK chemicals businesses was about guidance on navigating the new regulatory changes. Business concerns were customs procedures, potential delivery delays, origin requirements and, particularly, separate UK REACH and EU REACH obligations. Reports cited estimates of additional industry costs with the central concern that firms may need to purchase access to, or reproduce, safety information previously submitted within the EU system. Business concerns therefore centred on the affordability and predictability of compliance as well as regulatory standards. Relatedly, EU REACH involved use of testing data, with data ownership with another actor. A move to the UK REACH therefore translated to higher compliance costs as it included new data-sharing agreements.

While early regulatory alignment may have supported the export performance early on in the implementation period immediately after Brexit, reports show a subsequent decline in UK chemical output in 2023. Industry criticism of UK REACH early on and warnings about future divergence suggest that uncertainty can influence investment and market participation. Overall, the analysis does not establish that environmental regulation alone explains trade performance but points towards reducing unnecessary duplication, improving clarity and facilitating access to safety data while maintaining environmental protection.

5. Trade effects of TBTs

We assess the trade effects for UK exports in relation to the environmental TBTs notified and implemented by trading partners over the period 2010-2020. To do this, we use the gravity equation (Head and Mayer, 2014; Yotov, 2022), between the UK and all countries, using the following structural specification linking exports and notifications:

$$Y_{UKjkt} = \exp[GRAV_{UK,j,k,t}\gamma + \chi_{UK,k,t} + \pi_{j,t} + envTBT_{j,k,t}\beta]\varepsilon_{UK,j,k,t} \quad (1)$$

where the subscripts stand for the importer (j), the industry (k) and the year (t). In other terms, UK exports (Y_{UKjkt}) are regressed on bilateral and country-specific gravity covariates[20] (combined in $GRAV_{UK,j,k,t} = \{\alpha_{UK,j,k}; AVE_{UK,j,k,t}\}$, except for the exporter-time (χ) and importer-time (π) fixed effects) and on the importer-specific notifications for the protection of the environment ($envTBT$).[21] The model accounts for heterogeneity at sector level (*k*) and adopts a theoretically consistent set of fixed effects (Yotov et al., 2016). Exporter-product-time fixed effects α_{UKkt} control for all time-varying supply-side characteristics of UK. Importer-time fixed effects α_{jt} control for the importing country demand-specific characteristics. Sector-specific bilateral fixed effects α_{UKjk} account for any unobservable time-

[20] We control for the annual ad valorem equivalent of product-importer specific tariffs (AVE_{UKjkt}). Tariff data stems from Market Access Map (MAcMap) by CEPII.

[21] In line with the extant literature (e.g. Crivelli and Gröschl, 2016; Santeramo and Lamonaca, 2022), we use both dummy and count variables.

invariant bilateral component. The Poisson Pseudo Maximum Likelihood (PPML) estimator (Santos Silva and Tenreyro, 2006) controls for heteroskedasticity in trade data and zero trade flows. The random error term ε_{ijkt} is clustered at country-pair-product level, to account for heteroskedasticity and serial correlation that may occur in our large-N and small-T panel (Wooldridge, 2010). To allow for slow adjustments of trade to policy (e.g., Olivero and Yotov, 2012), we estimate the model on eleven years from 2010 to 2020. **Table 4** below presents a summary of key variables for the econometric analysis.

Table 4: Summary of variables

Variable	Description
Y_{UKjkt}	Annual UK bilateral exports of HS2-digit products from 2010 to 2020 (USD)
$envTBT_{j,k,t}$	- Annual number of environmental TBTs notified from UK partners on HS2-digit products from 2010 to 2020 (number) - Dummy variable equal to 1 if UK partners notify at least one environmental TBTs on HS2-digit products from 2010 to 2020
$AVE_{UK,j,k,t}$	Annual UK ad valorem equivalent of tariffs on HS2-digit products from 2010 to 2020 (percentage)

Source: Author's own.

The trade effects are based on equation (1) with two main variations. First, dummy variables flagging importers that notify environmental TBTs on the specific group of products being exported, capturing the effects on extant trading routes as it compares, across countries, the average export toward countries that have notified environmental TBTs vis-à-vis those that have not done so. These results are driven by the differences in imports from the UK, across sectors, for the same importer. Second, we use count variables on the total number of notifications being adopted in the destination market, looking at the average effects of an additional notification in those sectors where regulations are adopted; in other terms it allows us to compare, across notifiers that import from the UK partners, the volumes of exports in sectors with more notifications vis-à-vis the number of environmental notifications in less regulated sectors.[22]

The evidence (**Table 5**) suggests that, sector-wise, the environmental TBTs are not necessarily correlated with larger or smaller volumes of trade (column 1). The dummy variable is not statistically significant. Put differently, there is no significantly different volume of export toward more regulated sectors. Similarly, differences in stocks of notifications do not correlate with the volumes of exports (column 2).

These findings suggest that the UK did not consistently export more to notifying countries, and neither the opposite was true: the importing countries did not notify more measures on major importing sectors. Moreover, additional notifications did not imply statistically significant changes in UK exports. These results are confirmed throughout different specifications to rule out endogeneity issues and, more specifically, reverse causality.[23]

While this holds at the aggregate level, the same is not true when we disaggregate the effects across sectors,[24] insofar there is a marked heterogeneity in terms of volumes of trade toward notifying countries. Looking at sector specific effects, we found statistically larger UK exports of fats, organic chemicals, soap, pearls and articles of base metal as compared to sectors that are not regulated with TBTs for environmental protection (**Table S.1** in the Appendix). These sectors tend to be standards-intensive likely dominated by firms with strong regulatory, testing, and certification capacity. Exports may increase in these sectors because UK firms are relatively more competitive once standards tighten

[22] A further approach would be to combine (through interaction terms) the dummy and the count variables to flag the average effects of additional notifications, conditional of being a trading partner that regulates the sector through environmental TBTs.

[23] To test for endogeneity, we regressed environmental TBTs on exported lagged by one period. These results would say if the trade patterns in period *t-1* led to the initiation of the TBT in period *t* or not. We found no evidence of endogeneity. We test for reverse causality by dropping the *t* period value of TBT and running only for *t-1* period and then for *t-2*, *t-3*. We found no evidence of reverse causality. The results are reported in Appendix S.3 (table S.3 and table S.4).

[24] The results of the heterogeneity analysis are reported in Appendix S.3 (**Table S.5**).

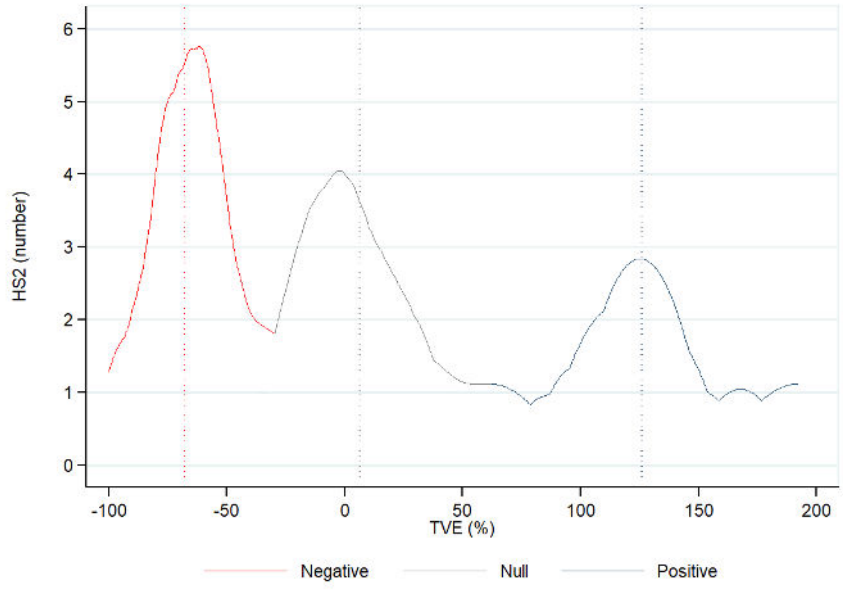
(Fontagné et a., 2015). Moreover, the volumes are substantially lower for cereals, oil seeds, tobacco, ores slag and ash, wood, headgear, and arms as compared to non-regulated sectors.

Another important element is the differential effect of additional notifications on exports. The marked cross-sectors difference is such that trade effects can be both positive, negative or null (**Figure 2**). The pro-trade effect is estimated to be as large as about +120 percent implying that an additional notification in sectors such as tobacco or explosives may double exports toward the notifying country. Conversely, the exports of sugars or metals tend to be contracted by about 60 percent when new measures are notified. Lastly, the exports of fish, dairy, plastics, rubber (and many sectors) are not affected by new notifications.

Based on the differential effects of additional notifications on exports for the UK, we categorise them broadly into three effect types: *i). A positive "expansionary effect" as seen for sectors like tobacco; ii) A negative "contractionary effect" of the type we find for UK exports of sugar; and iii). a "null effect" where new notifications have no discernible trade effects such as those observed in fish and rubber.*

Results specific for the chemicals sector suggest that arguably, the pro-trade effect hints at what is often termed as regulatory alignment (Baldock and Nicholson, 2022; Jones and Burns, 2024) – similarities in regulatory requirements between the UK and the main destinations for its exports. The EU has been a major destination for UK chemicals. However, it can be hypothesized that Brexit as of 2020 would have implied a clear change to this trend of regulatory alignment, and while we cannot account for a Brexit effect in our empirical analysis, the paper draws inferences based on our analysis of business perceptions.

Figure 2. Distribution of marginal effects on sectoral UK exports.



Source: Author's own.
Notes: Figure 2 shows the cross-sectors difference in trade effects (trade volume effects)- positive, negative or null, with the number of notifications at the HS 2-digit level on the Y-axis and the TVE in % on the X-axis.

Table 5. Effects of environmental TBTs on UK exports

Variables	(1) Presence	(2) Stock	(3) Presence and stock	(4) Presence in HS29, HS84	(5) Presence and stock in HS29, HS84	(6) Presence in HS29, HS84 of EU, USA, CHN	(7) Presence and stock in HS29, HS84 of EU, USA, CHN
Env-TBTs dummy	-0.0295		-0.0324	-0.0501	-0.0523	-0.0524	-0.0516
	(0.0317)		(0.0322)	(0.0333)	(0.0335)	(0.0335)	(0.0344)
Env-TBTs count (log)		0.0557	0.0567	0.0645	0.0968	0.0971	0.0920
		(0.0595)	(0.0594)	(0.0620)	(0.0828)	(0.0828)	(0.0813)
Env-TBTs dummy interacted with							
HS29				0.5127***	0.4992***	0.4670**	0.5109**
				(0.1826)	(0.1712)	(0.2025)	(0.2099)
HS29 of EU						Yes	yes
HS29 of USA						Yes	yes
HS29 of CHN						Yes	yes
HS84				0.0127	0.0549	0.0546	0.0426
				(0.1138)	(0.1125)	(0.1124)	(0.1129)
HS84 of EU						Yes	yes
HS84 of USA						Yes	yes
HS84 of CHN						Yes	yes
Env-TBTs count (log) interacted with:							
HS29					-0.0328	-0.0359	-0.0547
					(0.0902)	(0.0892)	(0.1509)
HS29 of EU							yes
HS29 of USA							yes
HS29 of CHN							yes
HS84					-0.1401	-0.1406	-0.0914
					(0.0999)	(0.0997)	(0.0850)
HS84 of EU							yes
HS84 of USA							yes
HS84 of CHN							yes(-*)
Dep. var.	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}
FE	$\alpha_{UKkt}, \alpha_{jt},$	$\alpha_{UKkt}, \alpha_{jt}$	$\alpha_{UKkt}, \alpha_{jt}$	$\alpha_{UKkt}, \alpha_{jt}$	$\alpha_{UKkt}, \alpha_{jt}$	$\alpha_{UKkt}, \alpha_{jt}$	$\alpha_{UKkt}, \alpha_{jt}$
Observations	81,419	81,419	81,419	81,419	81,419	81,419	81,419

Source: Author's own.

*Notes: The coefficient for 'HS84 of CHN' is -0.3033PPML estimates. All specifications controls for AVE (in log). Standard errors (in parentheses) are clustered at country-pair-product level. * p<0.10, ** p<0.05, *** p<0.01.*

6. Discussion

We investigated business perceptions on the stringency of regulations and links with trade effects of environmental regulations.

First, the data on environmental TBTs from 2010-2024, shows the highest degree of regulatory stringency in chemicals and machinery, with organic chemicals and mechanical machinery most strategic for the UK. Brexit in 2020 implied a change in the type of regulations in chemicals and machinery from enforcement measures to more technical regulations afterwards. UK notifications on environmental TBTs for chemicals doubled post-Brexit, with the most adopted technical regulations relating to tolerance limits for residues and restricted use of substances.

Second, the changes in business perceptions to regulations since 2020 suggests a possible alignment with the increase in regulatory stringency for the manufacturing sector in the UK. As UK firms prepared to navigate the new expected regulatory burdens post-Brexit in 2020, their perceptions mirrored the likely additional burden of compliance. However, these changes in perceptions were dependent on the sector and destination markets for exports of UK firms. The substantial reported burden from EU Exit over 2020-2024 was concentrated in trade-exposed sectors such as manufacturing. Exporting businesses reported significantly more difficulty with trade-related and EU exit regulation indicating a targeted trade-specific effect for manufacturing.

Third, the empirical analysis using data from 2010-2020 finds no significantly different volume of export toward more regulated sectors - UK exports were not systematically lower in more regulated sectors earlier, and differences in the stock of notifications were not significantly associated with UK export volumes.

Fourth, when we disaggregate the effects across sectors, we did find differential effects of additional TBT notifications on exports for the UK, a positive “expansionary effect”, a negative “contractionary effect”, and a “null effect” where new notifications have no discernible trade effects. The effects for the chemicals sector suggested a pro-trade effect.

Triangulating these findings, while we find an expansionary pro-trade effect for the UK from regulatory alignment using data from 2010-2020, it becomes clear that business perceptions on regulatory stringency were already beginning to change by 2019. With the news of Brexit weighing in from 2017, businesses started expecting major impediments from the government’s plans to transpose EU chemical regulatory system REACH (registration, evaluation, authorization, and restriction of chemicals) into UK law. In short, business perceptions were already changing prior to any regulatory changes coming into effect.

Following Brexit, the UK largely replicated EU legislative frameworks, ensuring continuity in regulatory standards across various sectors. This strategy was particularly evident in the chemical sector, where the EU REACH Regulation was transposed into UK law on 1 January 2021, becoming UK REACH. The pro-trade effect lines up with the literature that has shown similar evidence related to alignment in regulatory requirements (Baldock and Nicholson, 2022; Jones and Burns, 2024). With Brexit in 2020, a move to the UK REACH translated to higher compliance costs as it included new data-sharing agreements and ultimately led to a pessimistic business perception for the sector. While UK chemical exports performed better than expected immediately post-Brexit in 2020, as regulations remained in-line with EU rules, but afterwards, from 2021, the risk of regulatory divergence becomes clear.

Both UK REACH and EU REACH now function independently, requiring businesses to comply with both regulations where necessary. While the UK has largely retained and adapted EU regulatory frameworks, it has also introduced domestic policies in areas such as plastic pollution reduction and electric vehicle infrastructure.

In this case, aligning with the extensive literature on state-business relations, our evidence picks up on the importance of opening information channels between businesses and governments for regulatory formulation (Evans 1995, Rodrik 2009, Saha et al., 2019; Lim et al., 2021). At an aggregate level, as we find the importance of information and guidance for regulations, understanding business perceptions becomes specifically important for timely and systematic access to such guidance.

We highlight the importance of the role of businesses perceptions and how that can influence and inform responses from businesses. There may not always be an alignment between business perceptions of regulations and actual trade effects – while we see initially positive business responses early 2020s, these turn negative afterwards. At a time when businesses navigate complex trade and production landscapes in an uncertain global landscape, how and when businesses respond can have significant knock-on consequences for workers and consumers. Hence, through our analysis, we emphasise the importance of specific evidence to consider the role of business perceptions for environmental trade protection. Future research should explore the context-specific links between business perceptions and environmental trade protection in more detail.

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Appendix

S.0. Summary

Table A 1. Summary of literature on business perceptions and regulations

Context	Case	Method	Findings	References
Trade policy uncertainty (TPU)	UK textile firms after Brexit	Survey-based (688 firms, distributed throguh UK Fashion and Textiles Association)	Perceived effects of TPU vary depending on position, production phase, and degree of integration into GVC	Cassadei and Iammarino (2021)
Trade policy related barriers	SMEs (global)	Multiple global surveys	List of specific trade barriers. SMEs beginning to export face more barriers related to their internal capabilities, while experienced exporters report more barriers related to trade policy. Tariff barriers are important but emerging non-tariff barriers matter as much.	Fliess and Busquets (2006)
Labour regulatory stringency	Firms in LMICs	Survey-based (17,000 firms from 47 LMICs) (World Bank 'Doing Business dataset' and 'Investment Climate Survey'	Firms' perceptions on regulatory stringency are closely related to actual regulatory stringency	Pierre and Scarpetta (2006)
Barriers and opportunities for firm-level innovation	Use of nano-materials in consumer products	Survey-based (self made survey distributed to 300 US based firms working on water treatment	Costs and public opinion on safety of nanomaterials are biggest concerns.	Kidd et al. (2021)
Barriers to firm-level innovation	Innovation in Chilean firms	Survey-based (government survey 'Business Innovation Survey')	Multiple barriers identified, particularly emphasize relevance of non-financial barriers	Ortiz and Fernandez (2022)
Barriers to firm-level innovation	Innovative firms in Mexico and Turkey	Survey-based (government-made innovation surveys; looks at questions asking for perceived barriers to innovation)	Multiple barriers identified, barriers differ for small vs large firms.	De Fuentes et al. (2018)
Business' perception of economic policy uncertainty impact on innovation quality	Chinese firms	Textual analysis (based on corporate stock reports)	Perceptions of economic policy uncertainty don't affect innovation output (quantity of patent fillings) but do significantly affect innovation quality.	Jiang et al., 2024
Business' perception of regulations (general)	UK industries	Longitudinal cross-sector survey (through phone interviews with business managers)	Multiple (descriptive of survey/interviews)	BEIS (2019)

Context	Case	Method	Findings	References
Montreal Protocol	International environmental agreement to face out harmful chemicals	Text analysis using patent data	Restriction of chemical led to significant increase in R&D and innovation on alternatives	Digoua (2021)
Montreal Protocol	UK firm's perceptions of regulatory challenges	Interviews with business managers in chemical sectors	Environmental regulation favored large over small firms.	Purvis et al. (1997)
Environmental regulations effect on international competitiveness and green innovation	Firms affected by environmental regulations (in general)	Literature review (evidence assessment)	Environmental regulations only affect international competitiveness marginally and induces innovation in green technologies	Dechezleprêtre and Sato (2017)
SE Asia-EU/NorthAm. Environmental TBTs effect on business competitiveness	SE Asian Firms and green trade	Mixed (descriptive quant. data and literature review)	Environmental TBTs damage region competitiveness because firms don't yet have green capacity	Dahal and Pandey (2018)
US-EU Trade barriers imposed by EU environmental TBTs	Perceptions of U.S. SMEs (agriculture, manufacturing, services)	Roundtables, written submissions, and public hearings	SMEs are more affected from TBTs than large corporations. Multiple sector-specific barriers.	U.S. International Trade Commission
Environmental TBTs effect on green innovation	Preferential trade agreements (PTA) (worldwide)	PTA and bilateral trade flows dataset	Environmental TBTs favour firms with pre-established green capabilities, usually in high-income countries	Brandi et al. (2020)
Environmental TBTs effect on green innovation	Environmental TBTs and bilateral trade (global)	Novel environmental TBT dataset and bilateral trade data	Environmental TBTs favour firms with pre-established green capabilities, usually in notifying countries	Santeramo et al. (2025)
Environmental regulatory stringency effect on green trade	Trade in OECD countries	OECD's Environmental Policy Stringency index	Higher env. regulatory stringency associated with more trade in green products among OECD countries	Sauvage (2014)
Environmental regulatory stringency and FDI	Foreign investments by US and German MNCs, respectively	Survey-based (WEF business perception survey)	Less perceived env. Regulatory stringency associated with higher FDI (pollution haven effect)	Kelleberg (2009); Wagner and Timmins (2008)

Source: Author's own.

S.1. Environmental TBTs notified by the UK

Table S.1. Environmental TBTs notified by the UK

Document symbol	Distribution date	Entry into force date	Type of measure	UNCTAD classes	Harmonised sector	HS codes	Products covered
Pre-Brexit							
G/TBT/N/GBR/28	31/07/2017	30/06/2018	ENF	B1	CHE	33	Cosmetics and Personal Care products
G/TBT/N/GBR/29	01/02/2018	30/06/2018	ENF	B1	MAN	33	Cosmetics and Personal Care products
G/TBT/N/GBR/30	05/02/2018	19/06/2018	ENF	B1	MAN	33	Cosmetics and Personal Care products
G/TBT/N/GBR/31	19/02/2018	01/07/2018	ENF	B1	MAN	87	Motor vehicles
G/TBT/N/GBR/32	14/05/2018	01/09/2018	ENF	B1	MAN	33	Cosmetics and Personal Care products
G/TBT/N/GBR/33	18/01/2019	01/07/2019	ENF	B1	MAN	56	Plastic and cotton products
G/TBT/N/GBR/34	14/01/2020	01/04/2020	ENF, TEC	B1, B6	MAN	39	Furniture; plastic products
Post- Brexit							
G/TBT/N/GBR/35	06/04/2020	21/02/2021	CAP, TEC	B2, B8	MAN	84	Fuels
G/TBT/N/GBR/38	11/03/2021	-	TEC	B7	MAN	87	Electric Vehicle Charge points
G/TBT/N/GBR/40	30/07/2021	-	TEC	B7	MAN	85, 87	Electrical and electronic equipment
G/TBT/N/GBR/41	23/08/2021	01/06/2022	ENF	B1	MAN	39	Plastic products
G/TBT/N/GBR/43	24/09/2021	01/07/2022	TEC	B2	CHE, MAN	36, 90	Electrical and electronic equipment
G/TBT/N/GBR/46	16/03/2022	01/07/2022	TEC	B2	MAN	90	Electrical and electronic equipment
G/TBT/N/GBR/48	21/06/2022	01/01/2023	TEC	B7	MAN	40, 84, 85, 87, 94	Rubber; Electrical machinery and equipment; luminaires and lighting fittings; Motor vehicles; Furniture; prefabricated buildings
G/TBT/N/GBR/51	17/08/2022	01/07/2023	CAP	B8	MAN	39	Plastic product
G/TBT/N/GBR/53	13/09/2022	-	ENF	B1	AGR, CHE	38	Pesticides and other agrochemicals
G/TBT/N/GBR/54	17/10/2022	01/04/2024	ENF	B1	AGR, CHE	38	Pesticides and other agrochemicals
G/TBT/N/GBR/56	16/03/2023	01/02/2024	TEC	B2	MAN	85	Electrical and electronic equipment
G/TBT/N/GBR/58	30/03/2023	-	TEC	B3	CHE	28, 29, 38	Hazardous substances from chemical industry
G/TBT/N/GBR/59	03/04/2023	-	TEC	B7	MAN	85	Lighting Products
G/TBT/N/GBR/60	05/04/2023	01/10/2023	TEC	B3	CHE	28, 29, 38	Hazardous substances from chemical industry
G/TBT/N/GBR/67	24/08/2023	01/01/2024	TEC	B3	CHE	28, 29, 38	Hazardous substances from chemical industry

Notes: B1 (Import authorization/licensing related to technical barriers to trade), B2 (Tolerance limits for residues and restricted use of substances), B3 (Labelling, marking and packaging requirements), B6 (Product identity requirements), B7 (Product quality, safety or performance requirements), B8 (Conformity assessment related to TBT), ENF (enforcement), TEC (technical regulations), CAP (conformity assessment procedure), AGR (agriculture sector), CHE (chemical sector), MAN (manufacturing sector), 28 (Inorganic chemicals), 29 (Organic chemicals), 33 (Essential oils and resinoids; perfumery, cosmetic or toilet preparations), 36 (Explosives), 38 (Miscellaneous chemical products), 39 (Plastics), 40 (Rubber), 56 (Wadding, felt and nonwovens; special yarns; twine, cordage, ropes and cables), 84 (Machinery (mechanical)), 85 (Machinery (electrical)), 87 (Vehicles), 90 (Optical instruments), 94 (Furniture).

S.2. Environmental TBTs at the sector level

Table S.2. Sectors covered by environmental TBTs on organic chemicals, mechanical machinery, vehicles

				EU				GBR		USA			CHN			WLD	
				2010	2019	2023		2019	2023	2010	2023		2010	2023		2023	
HS2		HS4		nbr.	nbr.	nbr.	%	nbr.	nbr.	nbr.	nbr.	%	nbr.	nbr.	%	nbr.	%
29	Organic chemicals	-		18	194	259	98.5		3	8	183	97.9		6	54.5	552	87.5
		2903	*Halogenated derivatives of hydrocarbons*								2	1.1		1	9.1	18	2.9
		2933	*Heterocyclic compounds with nitrogen hetero-atom(s) only*													8	1.3
		2915	*Saturated acyclic monocarboxylic acids*			1	0.4									6	1.0
		2901	*Acyclic hydrocarbons*											1	9.1	4	0.6
		2921	*Amine-function compounds*													4	0.6
			Other		3	3	1.1			1	2	1.1		3	27.3	39	6.2
84	Mechanical machinery	-							1		3	1.9		2	2.6	41	3.7
		8415	*Air conditioning machines*		4	4	8.3			5	44	28.0		9	11.8	164	14.9
		8418	*Refrigerators*	2	9	9	18.8			7	34	21.7		9	11.8	161	14.6
		8414	*Air or vacuum pumps*	2	4	5	10.4			1	3	1.9	2	1	1.3	125	11.3
		8450	*Household or laundry-type washing machines*	2	7	7	14.6			1	1	0.6		1	1.3	88	8.0
		8422	*Dish washing machines*	2	4	4	8.3			1	9	5.7		1	1.3	44	4.0
			Other	2	15	19	39.6		1	21	66	42.0	5	55	72.4	521	47.2
87	Vehicles	-			9	13	46.4	1	2	1	2	4.8		7	15.6	159	35.7
		8703	*Motor cars*	1	7	7	25.0		1	8	22	52.4	1	18	40.0	83	18.7
		8704	*Motor vehicles (transport goods)*	1	5	6	21.4			3	1	2.4		6	13.3	50	11.2
		8702	*Motor vehicles (transport > 10 person)*		1	1	3.6		1		5	11.9	1	4	8.9	36	8.1
		8711	*Motorcycles*										1	1	2.2	24	5.4
		8705	*Special purpose motor vehicles*								3	7.1		3	6.7	21	4.7
			Other		1	1	3.6			1	9	21.4		6	13.3	72	16.2

S.3. Robustness checks and heterogeneity analyses

Table S.3. Effects of environmental TBTs on UK exports: controlling for endogeneity.

Variables	(1) Presence	(2) Stock
Bilateral trade	0.0023	0.0032
	(0.0057)	(0.0041)
Dep. var.	Env-TBTs dummy	Env-TBTs count
FE	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$
Observations	9,881	9,881

Notes: PPML estimates. All specifications controls for AVE (in log). Standard errors (in parentheses) are clustered at country-pair-product level. * p<0.10, ** p<0.05, *** p<0.01.

Table S.4. Effects of environmental TBTs on UK exports: controlling for reverse causality

Variables	(1) Presence, lag 1	(2) Presence, lag 2	(3) Presence, lag 3	(4) Stock, lag 1	(5) Stock, lag 2	(6) Stock, lag 3	(7) Presence and stock in HS29, HS84, lag 1	(8) Presence and stock in HS29, HS84, lag 2	(9) Presence and stock in HS29, HS84, lag 3
Env-TBTs dummy (lag 1)	-0.0553								
	(0.0433)								
Env-TBTs dummy (lag 2)		-0.0775**							
		(0.0342)							
Env-TBTs dummy (lag 3)			0.0405						
			(0.0363)						
Env-TBTs count (log, lag 1)				0.0301					
				(0.0595)					
Env-TBTs count (log, lag 2)					0.0076				
					(0.0491)				
Env-TBTs count (log, lag 3)						-0.0504			
						(0.0371)			
Env-TBTs dummy							-0.1052**	-0.0913*	-0.0780
							(0.0416)	(0.0547)	(0.0889)
Env-TBTs dummy interacted with									
HS29							0.6045***	0.7465***	0.6130***
							(0.1779)	(0.1779)	(0.2137)
HS84							-0.0454	-0.0956	-0.1053
							(0.1465)	(0.1564)	(0.2138)
Env-TBTs count (log)							0.1232	0.0735	0.0351
							(0.0790)	(0.0652)	(0.0625)
Env-TBTs count (log) * HS29									
lag1							-0.0080		
							(0.0820)		
lag2								0.0296	
								(0.1138)	
lag3									-0.1334
									(0.1352)
Env-TBTs count (log) * HS84									
lag1							-0.0999		
							(0.0687)		
lag2								0.0092	
								(0.0539)	
lag3									0.0615
									(0.0631)
lave	-0.0074	0.0274*	0.0005	-0.0070	0.0276*	0.0042	-0.0074	0.0248*	-0.0053
	(0.0179)	(0.0149)	(0.1835)	(0.0175)	(0.0148)	(0.1845)	(0.0179)	(0.0142)	(0.1832)
_cons	13.4566***	13.5196***	13.3529***	13.3982***	13.4723***	13.4180***	13.3797***	13.4359***	13.3625***
	(0.0334)	(0.0283)	(0.2582)	(0.0569)	(0.0450)	(0.2612)	(0.0675)	(0.0801)	(0.2650)
Dep. var.	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}	Y_{UKjkt}
FE	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$
Observations	67,122	52,971	38,965	67,122	52,971	38,965	67,122	52,971	38,965

Notes: PPML estimates. All specifications controls for AVE (in log). Standard errors (in parentheses) are clustered at country-pair-product level. * p<0.10, ** p<0.05, *** p<0.01.

Table S.5. Sectoral effects of environmental TBTs on UK exports

	(1)	(2)
Variables	**Presence in HS2**	**Stock in HS2**
Env-TBTs dummy	-0.0570	-0.0234
	(0.0801)	(0.0324)
Env-TBTs count (log)	0.0676	0.0747
	(0.0648)	(0.2577)
Sectoral dummies interacted with:	**env-TBTs dummy**	**env-TBTs count (log)**
HS01	0.0553	-1.0295***
	(0.2296)	(0.3871)
HS02	-0.0028	2.0319***
	(0.2780)	(0.3595)
HS03	-0.2874	-0.1465
	(0.1806)	(0.3703)
HS04	-0.1469	0.2621
	(0.1409)	(0.3526)
HS05	-0.0807	-0.3661
	(0.2282)	(0.3665)
HS06	-0.2088	0.4803*
	(0.2460)	(0.2886)
HS07	-0.1578	-0.1920
	(0.1749)	(0.3903)
HS08	-0.1693	-1.1228***
	(0.2172)	(0.3670)
HS09	0.3084	0.2240
	(0.2589)	(0.3704)
HS10	-1.1596**	-10.2961***
	(0.5910)	(0.3659)
HS11	-0.0791	1.0723***
	(0.1735)	(0.3026)
HS12	-1.5259***	1.1215*
	(0.4937)	(0.5846)
HS13	0.1661	1.1435***
	(0.1844)	(0.3601)
HS15	0.6716***	-0.6991**
	(0.1690)	(0.3273)
HS16	0.3959	2.1949***
	(0.3640)	(0.4141)
HS17	0.2268	-1.0147**
	(0.2743)	(0.4015)
HS18	0.1024	0.5693
	(0.1671)	(0.3510)
HS19	-0.1445	0.8888**
	(0.1462)	(0.3509)
HS20	-0.0144	0.7524**
	(0.1592)	(0.3712)
HS21	-0.0407	0.2642
	(0.1322)	(0.3850)
HS22	0.0211	0.1618
	(0.1327)	(0.2825)
HS24	-0.8557**	1.8156**
	(0.3505)	(0.7512)
HS25	0.1793	0.0191
	(0.1254)	(0.2984)
HS26	-0.9353***	-1.3757***
	(0.2744)	(0.4384)
HS27	-0.2721	0.1416
	(0.3300)	(0.4243)
HS28	0.5848	-0.1390
	(0.5126)	(0.3108)
HS29	0.5307***	-0.0992
	(0.2014)	(0.2625)
HS30	-0.0650	0.1465
	(0.1374)	(0.3145)
HS31	-0.2137	-0.1489
	(0.2353)	(0.2971)
HS32	0.1035	-0.0114
	(0.1155)	(0.2645)
HS33	-0.0957	-0.0703
	(0.2011)	(0.3032)
HS34	0.2250*	-0.0100
	(0.1276)	(0.2881)

HS35	-0.2588	0.2154
	(0.2376)	(0.3151)
HS36	No	0.7894***
		(0.2956)
HS38	0.1028	0.0070
	(0.1226)	(0.2602)
HS39	0.1190	-0.1507
	(0.1215)	(0.2777)
HS40	-0.0194	0.1806
	(0.1359)	(0.4371)
HS42	0.1013	-0.6775**
	(0.1730)	(0.2734)
HS44	0.1069	-0.1952
	(0.1995)	(0.5428)
HS47	-1.1532***	-2.4456***
	(0.2863)	(0.4483)
HS48	0.0580	-0.2547
	(0.1212)	(0.2669)
HS59	0.3481	0.3424
	(0.2126)	(0.2834)
HS63	0.1852	0.0557
	(0.1579)	(0.2903)
HS64	0.1373	0.7281
	(0.1985)	(0.7865)
HS65	-0.3819*	-1.0988***
	(0.2041)	(0.3204)
HS68	0.1072	0.1039
	(0.1279)	(0.2753)
HS69	-0.0890	-0.4201
	(0.2045)	(0.3310)
HS70	0.0591	-0.1438
	(0.1433)	(0.2771)
HS71	1.1113***	0.3630
	(0.3035)	(0.3142)
HS72	0.0742	-0.7682**
	(0.2130)	(0.3107)
HS73	-0.0416	-0.1118
	(0.1491)	(0.2636)
HS74	-0.1385	-0.4657
	(0.1649)	(0.2845)
HS75	0.2453	1.4584***
	(0.2004)	(0.3852)
HS76	-0.1411	-0.6091**
	(0.4231)	(0.2897)
HS82	-0.0225	-1.3077**
	(0.1105)	(0.6388)
HS83	0.2582*	0.3166
	(0.1338)	(0.3488)
HS84	0.0283	-0.1151
	(0.1379)	(0.2630)
HS85	0.0630	0.0565
	(0.1212)	(0.2663)
HS86	-0.1290	-0.0386
	(0.1526)	(0.2936)
HS87	0.1565	-0.0533
	(0.1754)	(0.2615)
HS89	-0.4976	-1.1967***
	(0.4174)	(0.2941)
HS90	0.0235	0.0535
	(0.1006)	(0.2553)
HS93	-1.1110***	-1.6816***
	(0.2933)	(0.4627)
HS94	0.0771	0.1385
	(0.1365)	(0.2839)
Dep. var.	Y_{UKjkt}	Y_{UKjkt}
FE	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$	$\alpha_{UKkt}, \alpha_{jt}, \alpha_{UKjk}$
Observations	81,413	81,419

Notes: PPML estimates. All specifications controls for AVE (in log). Standard errors (in parentheses) are clustered at country-pair-product level. * p<0.10, ** p<0.05, *** p<0.01.

S.4. Environmental TBTs at the sector level

Table S.6. Environmental TBTs at the sector level.

				EU				GBR		USA			CHN			WLD	
				2010	2019	2023		2019	2023	2010	2023		2010	2023		2023	
HS section		HS2		nbr.	nbr.	nbr.	%	nbr.	nbr.	nbr.	nbr.	%	nbr.	nbr.	%	nbr.	%
I	Animals	1	Live animals		1	1	0.1							1	0.3	16	0.3
		2	Meat		1	1	0.1							2	0.6	18	0.3
		3	Fish		1	1	0.1				1	0.1		2	0.6	26	0.4
		4	Dairy		1	1	0.1							2	0.6	86	1.4
		5	Animal origin products		1	1	0.1							2	0.6	8	0.1
II	Vegetables	6	Plants		1	1	0.1			1	3	0.3		1	0.3	18	0.3
		7	Vegetables		1	3	0.3							2	0.6	42	0.7
		8	Fruit		1	3	0.3							2	0.6	33	0.5
		9	Coffee		1	1	0.1							2	0.6	20	0.3
		10	Cereals		1	1	0.1							1	0.3	46	0.7
		11	Products of milling industry		1	1	0.1							1	0.3	15	0.2
		12	Oilseeds		1	1	0.1				1	0.1		2	0.6	32	0.5
		13	Resins		1	1	0.1							2	0.6	7	0.1
		14	Vegetable products		1	1	0.1									6	0.1
III	Fats	15	Fats and oils		1	1	0.1							2	0.6	24	0.4
IV	Food	16	Meat and fish preparations		1	1	0.1							2	0.6	29	0.5
		17	Sugars		1	1	0.1							2	0.6	39	0.6
		18	Cocoa		1	1	0.1							2	0.6	36	0.6
		19	Cereals preparations		1	1	0.1							2	0.6	44	0.7
		20	Vegetables preparations		1	3	0.3							2	0.6	47	0.8
		21	Miscellaneous preparations		1	1	0.1							2	0.6	35	0.6
		22	Beverages		1	1	0.1							3	0.8	38	0.6
		23	Residues from food industry		1	1	0.1									14	0.2
		24	Tobacco		1	1	0.1				1	0.1		1	0.3	23	0.4
V	Minerals	25	Salt								4	0.4		1	0.3	38	0.6
		26	Ores								1	0.1		2	0.6	8	0.1
		27	Mineral fuels	1	1	1	0.1			3	20	2.2	1	12	3.4	189	3.0
VI	Chemicals	28	Inorganic chemicals	20	196	263	24.2		3	10	182	20.0		8	2.2	590	9.5
		29	Organic chemicals	18	197	263	24.2		3	9	187	20.6		8	2.2	609	9.8
		30	Pharmaceuticals		1	1	0.1							1	0.3	15	0.2
		31	Fertilisers		1	9	0.8			1	6	0.7	1	2	0.6	175	2.8
		32	Tanning		1	2	0.2				4	0.4		8	2.2	106	1.7
		33	Cosmetics		1	3	0.3	4	4							102	1.6
		34	Soap	1	1	2	0.2			1	4	0.4		2	0.6	79	1.3
		35	Albuminoidal substances							2	3	0.3		2	0.6	10	0.2
		36	Explosives						1	1	4	0.4				12	0.2
		37	Photographic or cinematographic goods													2	0.0
		38	Miscellaneous chemicals	26	249	348	32.0		5	4	98	10.8	12	35	9.8	737	11.8
VII	Plastics	39	Plastics		2	4	0.4	1	4		6	0.7		3	0.8	170	2.7
		40	Rubber		1	1	0.1		1	1	2	0.2	1	4	1.1	59	0.9
VIII	Leather	41	Leather			1	0.1				1	0.1				5	0.1

		42	Leather articles			1	0.1				1	0.1		2	0.6	13	0.2
		43	Furskin													1	0.0
IX	Wood	44	Wood			1	0.1			2	5	0.6		3	0.8	54	0.9
		45	Cork											1	0.3	5	0.1
		46	Straw													2	0.0
X	Paper	47	Pulp of wood		1	1	0.1							2	0.6	13	0.2
		48	Paper			2	0.2							1	0.3	42	0.7
		49	Printed goods													2	0.0
XI	Textile	50	Silk													3	0.0
		51	Wool											1	0.3	3	0.0
		52	Cotton											1	0.3	3	0.0
		53	Other vegetable fibres													4	0.1
		54	Man-made filaments													4	0.1
		55	Man-made staple fibres											1	0.3	11	0.2
		56	Nonwovens													3	0.0
		57	Carpets								1	0.1				5	0.1
		58	Special woven fabrics													2	0.0
		59	Textile fabrics		1	2	0.2				1	0.1				25	0.4
		60	Knitted or crocheted fabrics													2	0.0
		61	Accessories, knitted or crocheted													7	0.1
		62	Accessories, not knitted or crocheted													7	0.1
		63	Other textiles			1	0.1				1	0.1	1	3	0.8	31	0.5
XII	Footwear	64	Footwear										3	5	1.4	20	0.3
		65	Headgear											1	0.3	5	0.1
XIII	Stone cement	68	Stone cement		2	2	0.2				1	0.1		2	0.6	29	0.5
		69	Ceramics			1	0.1						2	10	2.8	41	0.7
		70	Glass		1	2	0.2			1	3	0.3				25	0.4
XIV	Precious	71	Precious	1	1	1	0.1							3	0.8	7	0.1
XV	Metals	72	Iron and steel	1	1	1	0.1				2	0.2		3	0.8	21	0.3
		73	Iron and steel products			1	0.1				20	2.2		5	1.4	126	2.0
		74	Copper		1	2	0.2							5	1.4	18	0.3
		75	Nickel			1	0.1							1	0.3	6	0.1
		76	Aluminium	1	1	2	0.2							4	1.1	22	0.4
		78	Lead								1	0.1				4	0.1
		79	Zinc			1	0.1				1	0.1		1	0.3	5	0.1
		80	Tin			1	0.1				1	0.1		1	0.3	7	0.1
		81	Other metals			1	0.1							1	0.3	3	0.0
		82	Metal tools								3	0.3				12	0.2
		83	Miscellaneous metal articles			1	0.1									14	0.2
XVI	Machinery	84	Mechanical	10	33	36	3.3		2	26	160	17.6	5	73	20.5	766	12.3
		85	Electrical	7	39	65	6.0		4	19	101	11.1	10	49	13.8	714	11.5
XVII	Vehicles	86	Railway								2	0.2				15	0.2
		87	Vehicles	2	22	27	2.5	1	4	11	55	6.1	3	29	8.1	314	5.0
		88	Aircraft								4	0.4				7	0.1
		89	Ships								2	0.2		6	1.7	18	0.3
XVIII	Instruments	90	Optical		3	4	0.4		2		3	0.3		6	1.7	74	1.2
		91	Clocks and watches													3	0.0
		92	Musical											1	0.3	1	0.0

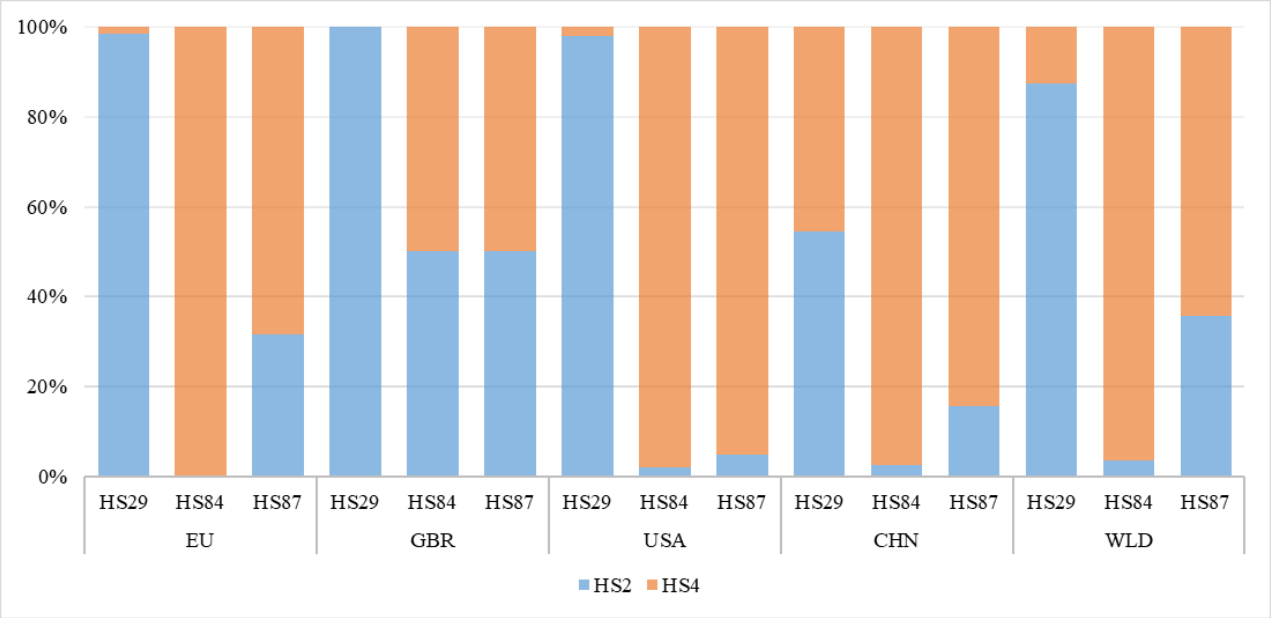
XIX	Arms	93	Arms							1	0.1				5	0.1
XX	Miscellaneous	94	Furniture				1	3	10	1.1	7	2.0	59	0.9
		95	Toys	2	4	0.4		2	2	0.2			32	0.5
		96	Miscellaneous manufactures										25	0.4
XXI	Art	97	Art										4	0.1

Table S.7. Sectors covered by environmental TBTs on organic chemicals, mechanical machinery, vehicles

				EU			GBR		USA		CHN	
HS2		HS4		2010 nbr.	2019 nbr.	2023 nbr.	2019 nbr.	2023 nbr.	2010 nbr.	2023 nbr.	2010 nbr.	2023 nbr.
29	Organic chemicals	-		18	194	259		3	8	183		6
		2901	Acyclic hydrocarbons									1
		2903	Halogenated derivatives of hydrocarbons							2		1
		2907	Phenols		1	1						
		2910	Epoxides							1		
		2912	Aldehydes						1	1		
		2914	Ketones and quinones		1	1						
		2915	Saturated acyclic monocarboxylic acids			1						
		2918	Carboxylic acids		1	1						
		2923	Quaternary ammonium salts and hydroxides									1
		2936	Provitamins and vitamins									1
		2942	Other organic compounds									1
84	Mechanical machinery	-						1		3		2
		8401	Nuclear reactors							6		
		8402	Steam boilers						2	7	1	3
		8403	Central heating boilers		2	2			3	1	1	2
		8404	Auxiliary plant for use with boilers						2	4		
		8406	Steam turbines							1		
		8407	Spark-ignition internal combustion piston engines		2	3			4	1	1	3
		8408	Compression-ignition internal combustion piston engines		2	3			1	11	1	6
		8409	Parts for internal combustion piston engines		2	3						
		8410	Hydraulic turbines							1		
		8411	Gas turbines						1	2		
		8412	Other engines and motors	1	1	1				2		
		8413	Pumps for liquids							9		7
		8414	Air or vacuum pumps	2	4	5			1	3	2	1
		8415	Air conditioning machines		4	4			5	44		9
		8416	Furnace burners					1	1	9		
		8417	Industrial or laboratory furnaces and ovens							1		2
		8418	Refrigerators	2	9	9			7	34		9
		8419	Machinery, plant or laboratory equipment		3	3			5	1		2
		8421	Centrifuges						1	1		3
		8422	Dish washing machines	2	4	4			1	9		1
		8424	Mechanical appliances		1	1				1		6
		8427	Fork-lift trucks									1
		8429	Self-propelled bulldozers									1
		8430	Other machinery for earth, minerals, ores									1
		8432	Agricultural machinery									1
		8433	Harvesting machinery									1
		8436	Other agricultural machinery									1
		8443	Printing machinery								1	1
		8450	Household or laundry-type washing machines	2	7	7			1	1		1
		8454	Converters	1	1	1						
		8465	Machine-tools									1

		8468	Machinery and apparatus for soldering, brazing, welding										2
		8470	Calculating machines										1
		8471	Automatic data processing machines		1	2			1	3			2
		8475	Machines for assembling electric lamps										1
		8476	Automatic goods-vending machines							2			
		8479	Machines and mechanical appliances having individual functions										2
		8481	Appliances for pipes, boilers, tanks, vats							3			5
87	Vehicles	-			9	13	1	2	1	2			7
		8701	Tractors							1			2
		8702	Motor vehicles (transport > 10 person)		1	1		1		5	1		4
		8703	Motor cars	1	7	7		1	8	22	1		18
		8704	Motor vehicles (transport goods)	1	5	6			3	1			6
		8705	Special purpose motor vehicles							3			3
		8706	Chassis fitted with engines										2
		8707	Bodies (including cabs)							2			
		8708	Parts and accessories		1	1				1			1
		8709	Works trucks							3			
		8711	Motorcycles								1		1
		8716	Trailers and semi-trailers						1	2			1

Figure A.1. Share of notifications applied to HS2 *versus* HS4 sectors.



Notes: HS29 is organic chemicals; HS84 is mechanical machinery; HS87 is vehicles.