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Environmental regulations and export quality:

Evidence from Austrian firms

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Abstract

This paper examines how technical barriers to trade (TBTs) in destination markets relate to the quality, sales, and market participation of Austrian manufacturing exporters. We combine export transactions for the 2013-2021 period with firm accounts, workforce characteristics, patents, tariffs, and TBT notification stocks. Benchmark instrumental-variable (IV) estimates associate total TBT exposure with higher demand-revealed quality and unit values and lower quality-adjusted prices among active exporters. The association between TBT exposure and quality is more consistent across specifications than the corresponding associations with trade volumes or entry decisions. Distinguishing between environmental and non-environmental TBTs indicates that the association with quality is mostly driven by environmental TBTs. Productivity and physical capital are associated with stronger quality and active-flow sales.

Keywords: environmental regulation, technical barriers to trade, exports, product quality, export market access, firm heterogeneity, Austria

JEL classification: F13; F14; F18; F64; D22; O31

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1 Introduction

Access to foreign markets increasingly depends on firms' ability to satisfy behind-the-border product requirements. Environmental technical barriers to trade (TBTs) are a prominent example. These measures regulate hazardous substances, emissions, energy efficiency, recyclability, environmental claims, labelling, testing, traceability, and production processes. They can address information asymmetries and environmental externalities while also imposing substantial trade costs. Compliance may require cleaner inputs, product redesign, new production equipment, laboratory testing, certification, and market-specific documentation. Regulation can therefore improve the attributes and credibility of products reaching the market while making participation more costly, potentially excluding those firms that are unable to bear the additional compliance costs. These compliance costs are particularly relevant in the case of environmental TBTs (Porter and van der Linde 1995; Ambec et al. 2013; Dechezleprêtre and Sato 2017; Essaji 2008; Fontagné et al. 2015). Against this background, this paper examines how Austrian manufacturing firms adjust export quality, sales, and market participation in response to TBT exposure in destination markets, distinguishing environmental and non-environmental TBTs.

The central empirical challenge is that the mechanisms operate on different margins and can have opposite signs. A regulation may raise observed unit values because marginal costs increase, because firms upgrade quality, or because low-quality exporters leave the market. It may increase sales among compliant incumbents while discouraging entry or terminating marginal firm–product–destination relationships. Treating every destination notification as an identical cost shock consequently obscures the respective quality, information, and selection channels. Therefore, aggregate product-level data are poorly suited to separate these channels because they combine the responses of surviving firms with changes in the set of exporters and products (Melitz 2003; Helpman et al. 2008; Khandelwal 2010; Feenstra and Romalis 2014).

This paper addresses this challenge with Austrian administrative microdata at the firm–product–destination–year level. Customs transactions for the 2013-2021 period are linked to firm accounts, employer–employee records, patent information, tariffs, and product-specific TBT notifications. The underlying positive-flow panel database contains 3.9 million observations covering 8,509 manufacturing firms, 4,339 six-digit Harmonized System (HS6) products, and 226 destinations. To study switching and zero trade, we construct an expanded panel of relationships observed exporting at least once. This structure permits a joint analysis of demand-revealed quality, unit values, prices net of quality, export sales, and firm entry and exit.

The empirical strategy distinguishes quality, sales, and participation outcomes. Demand-revealed quality is recovered from firm-level quantities and unit values under constant elasticity of substitution (CES) demand, following Khandelwal (2010), Khandelwal et al. (2013), and Fan et al. (2015). We estimate value and physical volume separately, both conditional on positive flows and in the expanded panel including zeros. Linear instrumental-variable (IV) specifications use simple leave-one-out worldwide same-product and own-destination other-product notification averages as instruments. The linear IV specifications, including entry and exit, use two-step IV-GMM (generalised method of moments), while export value and volume in levels are also estimated by IV Poisson with generated fixed-effect components. Probit estimates are confined to

the one-stage appendix specifications. The one-stage models include firm, product–destination, and destination–year effects and cluster standard errors by destination–product; product–year effects provide a stricter robustness exercise.

The paper provides three contributions to the empirical literature. First, it extends the quality-and-NTM (non-tariff measure) analysis in Ghodsi (2023) from bilateral product aggregates to observed firm–product–destination relationships and their export histories. It complements firm-level evidence on regulatory upgrading and selection in China, Peru, and France (Hu et al. 2019; Doan and Zhang 2024; Curzi et al. 2020; Disdier, Gaigné, et al. 2023) with an application to Austrian manufacturing exporters. The linked administrative data permit a common analysis of demand-revealed quality, unit values, quality-adjusted prices, positive export value and physical volume, relationship entry and exit, and export outcomes including zeros within the observed relationship universe. This design assesses whether favourable outcomes among active exporters coincide with improved participation and trade. Second, the paper distinguishes environmental from non-environmental destination TBT exposure across these outcomes.

Third, linking export transactions to firm accounts, employer–employee records, and patent information allows us to compare regulatory associations with firm characteristics, such as employment, skill intensity, physical capital, software capital, total factor productivity (TFP), and patents (Kugler and Verhoogen 2012; Fontagné et al. 2015; Disdier, Gaigné, et al. 2023).

The paper asks four related questions. First, do destination TBTs primarily raise the scale and quality of exports that remain in the market? The benchmark IV estimates associate total destination TBT exposure with higher quality and unit values, lower quality-adjusted prices, and higher export value among active flows. The one-stage regressions reproduce this price–quality pattern, and the positive total-stock quality association remains after adding product–year effects. Physical volume among active flows is statistically insignificant. In the zero-inclusive IV Poisson specification, value is statistically insignificant and volume negative, while the positive benchmark entry association loses significance with product–year effects. The evidence therefore points more consistently to upgrading among observed exporters than to an expansion in trade or market access.

Second, are environmental TBTs distinctive in their quality effects relative to non-environmental technical regulation? The environmental/non-environmental comparison is more sensitive to specification. Environmental TBTs are associated with higher quality and export value among active flows but lower zero-inclusive IV Poisson value and volume in the disaggregated benchmark. Non-environmental TBTs have a statistically insignificant quality association and higher quality-adjusted prices, while their sales associations differ between active flows and the expanded panel. The environmental quality association becomes statistically insignificant with product–year effects. Overidentification tests reject the restrictions in the disaggregated linear benchmark, so these category contrasts should be interpreted as empirical patterns rather than established causal effects.

Third, do destination effects differ when home standards and other shocks common to each product and year are taken into account? The product–year fixed-effect specifications instead check whether associations with destination regulation survive common product–year shocks,

including home regulatory developments shared across destinations. The positive association between total TBT exposure and export quality remains statistically significant, although its magnitude falls to less than half of the benchmark estimate, while the environmental TBT quality association and the positive total TBT entry association lose statistical significance.

Fourth, how do productivity, size, skills, physical capital, software capital, and patenting moderate the association between total TBT exposure and export outcomes at the firm level? Results suggest that capital intensity and TFP are associated with stronger conditional quality and sales responses, skills with a stronger positive-flow value and volume response, and software and patents with different conditional and zero-inclusive margins.

The remainder of the paper is organised as follows. Section 2 reviews the related literature and positions the contribution. Section 3 describes the data and empirical strategy. Section 4 presents and interprets the results, and the final section concludes.

2 Literature review

The paper sits at the intersection of five literatures that are usually developed separately: environmental regulation and induced innovation; trade and the location of regulated production; product standards and non-tariff measures; endogenous product quality and heterogeneous exporters; and the diffusion of destination-market rules across countries. Reviewing them jointly is important because environmental TBTs can simultaneously change product attributes, the credibility of those attributes, variable production costs, fixed and sunk compliance costs, and the composition of exporting firms. No single one of these literatures is therefore sufficient to interpret the measured quality, price, value, volume, and participation outcomes at the same time.

2.1 Environmental regulation, innovation, and competitiveness

The conventional view treats environmental regulation as a constraint that raises firms' costs and can reduce output, investment, employment, or international competitiveness. Early reviews found that environmental compliance costs were often small relative to other determinants of plant location and trade, but they also emphasised severe measurement and endogeneity problems in empirical measures of regulatory stringency (Jaffe et al. 1995). The Porter hypothesis challenged the purely static cost view by arguing that appropriately designed regulation can reveal inefficiencies, stimulate innovation, and partially offset compliance costs through improved resource productivity (Porter and van der Linde 1995; Porter 1996). Subsequent reviews conclude that neither the strong Porter hypothesis nor the pure cost hypothesis holds universally: effects depend on the instrument, enforcement, technological opportunities, market structure, and the outcome being measured (Ambec et al. 2013; Dechezleprêtre and Sato 2017; Cohen and Tubb 2018).

A large theoretical and empirical literature nevertheless supports the narrower proposition that prices and regulation can redirect innovation. Popp (2002) shows that energy prices induce

energy-saving patenting, while Acemoglu et al. (2012) formalise how environmental policy directs technical change between clean and dirty technologies. Firm-level evidence confirms that policy affects not only the level but also the direction of innovation. The EU Emissions Trading System increased low-carbon patenting among regulated firms (Calel and Dechezleprêtre 2016); higher fuel prices redirected automotive innovation towards clean technologies, with strong path dependence in firms' prior knowledge stocks (Aghion et al. 2016); and detailed evidence on European vehicle standards shows that firms can respond through genuine technology adoption, product adjustment, and strategic compliance (Reynaert 2021). Recent evidence on chemical regulation similarly finds induced innovation and substitution away from hazardous inputs, with responses shaped by firms' technological flexibility and positions in value chains (Kang et al. 2026). These findings motivate the innovation and quality-upgrading channels in the present paper, but they do not imply that innovation offsets all compliance costs or that every firm can make the required investment.

Regulation also reallocates activity across plants, firms, and workers. Greenstone (2002) documents that the US Clean Air Act reduced activity in pollution-intensive plants in non-attainment areas, while Walker (2013) shows that regulation generated meaningful transitional earnings losses through worker reallocation. At the same time, much of the long-run decline in US manufacturing pollution reflects cleaner production techniques rather than a simple shift in industrial composition or imports (Levinson 2009; Shapiro and Walker 2018). Recent work further shows that regulation can affect entry differently from exit, making the extensive margin state dependent rather than a single participation response (Li and Wang 2025). The implication for this paper is that favourable outcomes among surviving exporters can coexist with exclusion or reallocation elsewhere. It is therefore necessary to analyse positive sales, entry, exit, and zero-inclusive exports separately.

A related theoretical literature studies minimum-quality or environmental standards as changes in market structure rather than merely marginal-cost shocks. In vertically differentiated markets, a public standard can eliminate low-quality varieties, intensify quality competition, and lower quality-adjusted prices even when nominal prices rise (Leland 1979; Ronnen 1991; Crampes and Hollander 1995). With heterogeneous firms and endogenous quality, raising a standard can induce productive firms to upgrade while forcing marginal firms to contract or exit (Gaigné and Larue 2016; Macedoni and Weinberger 2022). General-equilibrium models show that quality regulation may generate cross-border spillovers and a rationale for international cooperation but can also reallocate market shares towards high-quality firms and countries (Mei 2024; Macedoni and Weinberger 2025). These studies motivate examining quality adjustment alongside changes in sales and participation, without presuming that favourable outcomes among active exporters extend to all firms.

2.2 Environmental regulation, trade, and exporter adjustment

The trade-and-environment literature traditionally asks whether differences in domestic environmental stringency alter comparative advantage, industrial location, and pollution. The canonical scale–composition–technique decomposition shows that trade can change pollution through

several offsetting channels (Antweiler et al. 2001; Copeland and Taylor 2004). Empirical evidence on the pollution-haven effect is correspondingly mixed. Ederington et al. (2005) show that pollution-intensive industries are often relatively immobile, which weakens simple correlations between regulation and trade. After addressing unobserved heterogeneity and the endogeneity of abatement costs, Levinson and Taylor (2008) find that tighter US regulation increased net imports in affected industries. This literature establishes that regulatory costs can influence trade patterns, but it generally studies domestic emissions rules at an industry level rather than foreign product requirements faced by individual exporters.

Firm-level studies sharpen the picture. Environmental regulation can reduce firms' export participation or sales by raising production and abatement costs (Shi and Xu 2018; Zhang et al. 2020). It can also induce upgrading: mandatory pollution abatement has been linked to higher export-product quality (Xiong and Zhu 2023), and recent evidence suggests that environmental requirements in foreign markets can transmit cleaner production practices back through exporting relationships (Kong et al. 2026). These studies are closer to the present application because they allow regulation to affect firms and products heterogeneously. However, domestic pollution regulation and foreign product regulation remain conceptually different. While the former primarily changes production technology and emissions costs, the latter can additionally impose product-specific minimum requirements as well as certification and documentation obligations in addition to providing information about product attributes that consumers in the destination market value.

This distinction matters for interpreting prices and exports. Evidence on destination standards shows that quality adjustment and exporter selection can occur together (Disdier, Gaigné, et al. 2023). Compliance costs may reduce participation, while demand for certified or higher-quality varieties supports sales for some exporters. The paper examines these outcomes jointly using firm-level data, supplementing evidence on aggregate trade and industrial relocation.

2.3 Product standards and non-tariff measures

Product standards have long been recognised as both market-correcting institutions and potential barriers to trade. They can reduce information asymmetry, improve compatibility and safety, and define a minimum acceptable quality (Leland 1979; Ronnen 1991). Common standards may also provide information and reduce transaction costs, which can expand trade (Swann et al. 1996). Yet compliance requires technical, human, and organisational resources. Essaji (2008) shows that technical regulation shifts specialisation away from countries with weaker compliance capacity, and Disdier, Fontagné, et al. (2008) find that TBTs and sanitary and phytosanitary (SPS) measures disproportionately restrict agricultural exports from developing and least-developed economies. The sign of a regulatory NTM is therefore not inherent in its legal classification; it depends on the quality, information, and cost channels it activates.

Recent evidence focuses explicitly on technical measures notified for environmental protection. Santeramo et al. (2025) combine WTO notifications with bilateral HS6 trade data for 2010–2020 and find that environmental TBTs reduce trade values and physical volumes, without a statistically significant effect on unit values in their baseline estimates. The effects vary

substantially across sectors and are more restrictive for exporters from countries that do not themselves notify environmental TBTs. These findings suggest that the trade implications of environmental requirements depend partly on exporters' compliance capacity and their domestic regulatory environment.

Lamonaca and Santeramo (2025) extend this evidence using sector-level trade data for 2008–2021 and a broader environmental TBT dataset that maps notifications lacking HS codes to sectors. They combine domestic and international trade flows and interact environmental TBT exposure with a border indicator, allowing its effect to be identified alongside importer–sector–year fixed effects. Their estimates indicate that environmental TBTs restrict international trade relative to domestic trade. We complement these aggregate analyses by examining demand-revealed quality, quality-adjusted prices, and separate sales and participation outcomes at the firm–product–destination level.

Firm-level evidence reveals different responses across export margins and firm sizes. Restrictive SPS measures raised as trade concerns reduce export participation and sales, with smaller exporters bearing larger adverse effects (Fontagné et al. 2015). Product standards also alter firms' decisions to enter particular products and destinations (Fernandes et al. 2019). In agri-food trade, compliance can improve quality while reducing the participation of less capable firms (Curzi et al. 2020). A quasi-experimental study of an EU product requirement finds that affected Chinese exporters upgraded quality even as export values and volumes declined and less productive firms exited (Hu et al. 2019). Using French firm–product–destination data, Disdier, Gaigné, et al. (2023) show that standards can favour high-productivity, high-quality firms, raise their sales, and induce quality signalling and upgrading. These results imply that an average trade coefficient can conceal a simultaneous rise in conditional sales and fall in participation. Using Chinese firm-level customs data matched with WTO Specific Trade Concerns, Doan and Zhang (2024) show that TBTs increase exporters' probability of exit, while surviving firms expand export sales, charge higher unit values, upgrade product quality through greater research and development and imported intermediate and capital inputs, and ultimately exhibit lower quality-adjusted prices. Their results provide direct evidence that technical regulations simultaneously induce quality upgrading and exporter selection, implying that aggregate trade effects mask important differences between the extensive and intensive margins.

The broader NTM literature also stresses heterogeneity across measures, products, destinations, and exporters. TBTs can reduce the extensive margin while supporting the intensive margin of existing trade (Bao and Qiu 2012). Their effects depend on exporter productivity and destination characteristics (Ghodsi 2020). Technical regulation can favour higher-quality varieties and alter observed unit values even when average trade falls (Hyun and Jang 2022; Ghodsi and Stehrer 2022). The product-level framework in Ghodsi (2023) formalises TBTs and SPS measures as ad valorem, specific, and fixed compliance costs in addition to estimating their effects on quality and quality-adjusted prices using bilateral HS6 data. The present paper examines related questions using observed firm-level relationships, allowing quality, sales, and participation outcomes to be analysed separately.

The complementary product-level gravity analysis by Artuso et al. (2026) estimates highly

heterogeneous TBT and SPS trade effects and tariff equivalents at the HS6 level. Its central identification difficulty is that importer–product–year fixed effects appropriate for inward multilateral resistance can absorb non-discriminatory importer–product regulation. Observing Austrian firm-level outcomes within a destination–product and exploiting regulatory changes over time permits the present price–quality and participation analyses, but it does not eliminate common time-varying product shocks or resolve the choice of comparison group. The two levels of analysis thus answer two different questions.

Two measurement issues from this literature are central here. First, the count or stock of notifications is an imperfect proxy for latent regulatory stringency: measures differ in scope, enforcement, and compliance technology. General concerns about measuring environmental stringency apply equally to notification-based trade regulation (Brunel and Levinson 2016). Second, regulation is endogenous. Governments may regulate in response to import growth, safety incidents, lobbying, technological change, or shifts in consumer demand. This motivates the high-dimensional fixed effects and leave-one-out instruments used below, while the possibility of common international regulatory shocks requires a cautious interpretation of the IV estimates.

2.4 Endogenous quality, prices, and heterogeneous exporters

The quality literature explains why unit values cannot be read mechanically as costs. Countries with higher incomes demand higher-quality goods, and exporters sort across products and destinations partly through quality (Hallak 2006; Hummels and Klenow 2005). Within narrowly defined products, unit values vary systematically with exporter characteristics and production techniques (Schott 2004). At the firm level, more productive plants can use higher-quality inputs, employ more skilled workers, produce higher-quality outputs, and charge higher prices (Verhoogen 2008; Kugler and Verhoogen 2012; Manova and Zhang 2012). Direct quality measures for French wine confirm that quality raises prices, export values, and the probability of entering foreign markets (Crozet et al. 2012). Exporting to high-income destinations can itself increase demand for skilled labour because higher quality is more costly to provide (Brambilla and Porto 2016).

Several models make quality choice endogenous within heterogeneous-firm trade. Hallak and Sivadasan (2013) distinguish process productivity from the ability to produce quality at low fixed cost. Antoniades (2015) shows how firms jointly choose quality and export participation, while Feenstra and Romalis (2014) embed endogenous quality on both the demand and supply sides. Fan et al. (2015) demonstrate that changes in trade policy can alter firms' quality and pricing decisions, and Flach and Unger (2022) show that quality changes the mapping between trade costs and gravity. These models imply that a high observed price may reflect high marginal cost, high quality, or both, and that firms with similar productivity can differ in their ability to comply with a quality requirement.

Demand-based quality estimators exploit the idea that, conditional on price and market conditions, a variety with unusually high demand has higher unobserved quality (Khandelwal 2010; Khandelwal et al. 2013). This approach is well suited to the present setting because environmental regulation may affect both quantities and unit values. We recover a demand-revealed quality

index at the firm–product–destination–year level and define the quality-adjusted price as the unit value net of estimated quality. The decomposition permits a sharper interpretation than unit values alone: a regulation that raises unit values but raises estimated quality by more is associated with a lower price per unit of valued attributes, whereas a rise in the quality-adjusted price points more directly to a net compliance-cost channel.

Quality choice also interacts with export dynamics. Heterogeneous-firm models distinguish the intensive margin of incumbent sales from the extensive margin of market participation (Melitz 2003; Helpman et al. 2008). Empirical and structural work shows that sunk entry costs create persistence and separate entry from continuation decisions (Roberts and Tybout 1997; Das et al. 2007). Environmental certification and destination-specific redesign are natural sources of such sunk costs. These findings motivate analysing entry, exit, positive sales, and zero-inclusive exports separately. Better performance among selected active exporters need not imply wider market access, and the distinct participation histories of entrants and continuing exporters warrant separate attention.

Observed firm characteristics may also capture different resources relevant to regulatory adjustment. TFP most directly captures process efficiency, but regulatory adaptation can depend on engineering capacity, skilled labour, physical capital, digital traceability systems, managerial scale, and product-specific knowledge. Existing evidence that standards are less restrictive for large firms (Fontagné et al. 2015) and that quality provision is skill intensive (Verhoogen 2008; Brambilla and Porto 2016) suggests that these capabilities need not moderate regulation identically. We therefore interact regulatory exposure separately with employment, skill intensity, capital intensity, software capital, TFP, and patent intensity, using logs for employment and capital, software, and patent intensity, a percentage-point skilled-worker share, and the TFP measure in the units reported in the tables rather than constructing a single composite capability index.

2.5 Destination standards, regulatory objectives, and diffusion

Evidence on standards illustrates why a notified destination measure cannot be treated as a simple trade tax. Harmonised technical rules have been associated with higher trade and product quality, alongside heterogeneous adjustment costs borne by exporters (Schmidt and Steingress 2022; Shingal and Ehrich 2024; Fiankor and Shingal 2025). These findings inform the interpretation of possible demand and cost effects of technical requirements. Our estimates, however, concern exposure to the destination's notified TBT stock rather than the effect of harmonisation.

The objectives recorded in WTO notifications can also matter for economic interpretation. Using WTO I-TIP keywords to compare TBT and SPS policy objectives across trading partners, Ghodsi and Sabouniha (2026) find a negative association between bilateral objective distance and trade. The present paper uses the same notification source for a different purpose: we count destination TBTs in force and classify the environmental component principally from notifications whose keyword field contains 'environment'. This is an objective-based description of notified measures; it is not a measure of their legal stringency, environmental efficacy, or

bilateral compatibility. Another related study finds that technological proximity can moderate the trade effect of compliance-intensive NTMs (Ghodsi, Landesmann, et al. 2026); our Austrian firm interactions instead concern observed capabilities and destination stock exposure.

Regulatory adoption diffuses across destinations and products. Recent evidence identifies export markets as an important source of regulatory diffusion (Rocha and Thakur 2026). This supports the relevance of destination notification stocks but complicates the instruments based on other markets' and other products' measures: correlated safety concerns, product-specific technological change, or demand could affect Austrian exports directly. The product–year and destination–year controls address common observed patterns, but the exclusion restriction and reported overidentification tests remain essential.

3 Empirical methodology and data

3.1 Data sources and estimation samples

The analysis combines transaction-level trade data with firm- and worker-level information available through the Austrian Micro Data Center (AMDC). Destination TBT exposure is constructed from the WTO's Integrated Trade Intelligence Portal (I-TIP) notifications, and bilateral tariffs from the World Integrated Trade Solution (WITS). Table 1 summarises the linked data sources.

We use Austrian Extrastat and Intrastat customs records[1] to construct a firm-level export panel. Only export transactions by manufacturing firms in NACE Rev. 2 divisions 10-33 are retained, excluding division 19 (manufacture of coke and refined petroleum products). Transactions are aggregated to firm (f), HS6 product (h), destination (j), and year (t). The initial positive-flow panel contains 3,912,240 firm–destination–product–year observations, 8,509 firms, 226 destinations, 4,339 HS6 products, and 1,378,019 distinct firm–destination–product relationships.

WTO notifications and the environmental classification. The WTO I-TIP database records TBT notifications by notifying member and includes measure type, relevant dates, products covered, and keyword fields describing the notified measure's stated purpose. We align product scopes to HS six-digit categories, identify notifications in force in each year, and match the resulting destination–product–year stocks to Austrian firm transactions. The historical regulatory series extends before the 2013-2021 export panel so that a measure already in force at the beginning of the export sample contributes to the relevant stock. Product mapping and objective harmonisation in the related wiiw notification database are documented by Ghodsi, Grübler, et al. (2017).

The environmental classification is based principally on TBT notifications for which the WTO keyword field contains 'environment'. The remaining TBTs constitute the non-environmental component, and the two components sum to the total stock for each destination–product–year

[1] Intrastat records trade in goods between Austria and other European Union (EU) member states, whereas Extrastat records trade between Austria and non-EU countries based on customs declarations.

cell. This tag records a stated policy objective, not a direct assessment of the legal content, strictness, compliance costs, abatement, or environmental performance of the measure. It can omit environmentally relevant TBTs described under other keywords and can include measures with several objectives. A notification that covers multiple HS6 products contributes to the stock for each covered product; counting it across products does not imply several distinct legal instruments for the same product.

Environmental goods. The environmental-goods robustness sample follows the product classification used by Artuso et al. (2026). It combines the environmental-goods coverage of Annex B.11 of the Agreement on Climate Change, Trade and Sustainability (ACCTS) with that of the Singapore-Australia Green Economy Agreement. Consolidating the two lists yields 517 distinct six-digit products in the HS 2022 nomenclature. This list provides an operational classification for the robustness exercise rather than a universally agreed definition of environmental goods.

Applied bilateral tariffs. We draw tariffs on Austrian exports by destination, HS6 product, and year from WITS, which compiles the WTO Integrated Database and UNCTAD's Trade Analysis and Information System (TRAINS). Available preferential rates are prioritised, followed by effectively applied rates and then most-favoured-nation (MFN) rates; where feasible, specific and compound duties are converted to ad valorem equivalents, and missing years are filled with the simple average of the two temporally closest available observations. The corresponding ad valorem tariff, expressed in percentage points (pp), enters the regressions as $\ln(1 + Tariff_{hjt})$, retaining zero tariffs. These tariff observations are a bilateral trade-policy control rather than the paper's regulatory treatment. For intra-EU trade relationships, tariffs and the measured destination TBT exposure are coded as zero. This is a maintained empirical convention for trade within the single market; it does not imply that EU technical or environmental requirements are absent. Extra-EU estimates therefore provide an important scope check.

Table 1: Main data sources

Dataset	Role in the analysis
Austrian Extrastat and Intrastat	Firm-level export transactions by destination, product, and year
Austrian Business Register (LSE-ARB)	Firm-level balance-sheet information used to construct employment, capital intensity, software capital, patent stock, total factor productivity, and other firm characteristics
Austrian Employee Data (AEST)	Employee-level educational attainment used to construct the firm-level share of highly educated workers
WTO I-TIP Technical Barriers to Trade database	Product–destination–year technical barriers to trade
WITS tariff database	Applied bilateral tariffs
Patent data	Moody's Orbis Intellectual Property

To study zero exports and switching, we expand every firm–destination–product relationship observed at least once over the 2013-2021 period to all sample years. Inactive years are assigned an export value of zero. This approach avoids the infeasible Cartesian product of every firm, product, and destination, but it also defines the extensive-margin estimand: entry and exit are measured within the set of relationships that export at least once during the sample, not against the universe of all possible relationships. The expanded panel contains 12,402,171 firm–destination–product–year observations, corresponding to 1,378,019 distinct relationships observed over nine years, before the estimation restrictions are applied. After applying the estimation-period restrictions, excluding observations with missing required variables, and accounting for estimator-specific exclusions, the estimation samples contain 3,307,996 observations for the price–quality and positive-volume equations, 3,783,565 in the IV positive-value equation, 11,043,888 in the full-panel log-one-plus and participation IV-GMM equations, and 11,029,145 in the main IV Poisson equations; the one-stage Poisson pseudo-maximum likelihood (PPML) estimation samples vary slightly by outcome.

The positive-flow sample is used for demand-revealed quality, unit values, quality-adjusted prices, and positive export value and volume. The expanded panel is used for entry, exit, and zero-inclusive export value and volume. Appendix Table A.1 provides definitions of the empirical variables and estimation notation.

3.2 Measuring demand-revealed export quality

Under the CES demand approach used by Khandelwal et al. (2013), varieties with greater demand conditional on price and market conditions are assigned higher quality. Following this approach, as also applied by Fan et al. (2015) and Fauceglia (2020), we estimate

$$\ln q_{fhjt} + \sigma_h \ln p_{fhjt} = \iota_h + \iota_{jt} + \nu_{fhjt}, \tag{1}$$

where q_{fhjt} is physical export quantity, p_{fhjt} is the unit value, ι_h are product fixed effects, ι_{jt} are destination–year fixed effects, and σ_h is the product-level elasticity of substitution from Broda et al. (2017). Estimated log effective quality is

$$\ln \widehat{\mathcal{Z}}_{fhjt} = \frac{\widehat{\nu}_{fhjt}}{\sigma_h - 1}, \tag{2}$$

and the log quality-adjusted price is

$$\ln \widetilde{p}_{fhjt} = \ln p_{fhjt} - \ln \widehat{\mathcal{Z}}_{fhjt}. \tag{3}$$

The estimated quality index $\widehat{\mathcal{Z}}_{fhjt}$, defined in Equation (2), should be interpreted as effective, demand-revealed quality. It can increase because the engineering attributes of the variety improve, because certification makes those attributes more credible, because unobserved delivered costs fall, or because these channels occur jointly. The reported quality association does not represent a causal improvement in the same surviving varieties, as it can also reflect changing composition and unobserved product-market appeal. The reason for this is that the positive-flow sample

includes entrants as well as continuing relationships. Firm and product–destination fixed effects do not hold the composition of firm–product–destination relationships constant, and conditioning on positive exports can select firms whose responses differ from those of inactive or excluded relationships.

The identity in Equation (3) is also useful for internal consistency: for estimators that apply the same linear mapping to all three outcomes, the unit-value coefficient equals the sum of the quality and quality-adjusted-price coefficients on an identical sample. This requires common regressors, instruments, fixed effects, and estimation weights; separate two-step IV-GMM equations can use different estimated moment weighting matrices.

3.3 Regulatory exposure, export states, and outcomes

Let N^g_{hjt} count TBT notifications in force in destination j for product h in year t and category $g \in \{TBT, Env, NonEnv\}$. The environmental component is based primarily on the occurrence of 'environment' in the WTO I-TIP keyword field; $N^{TBT}_{hjt} = N^{Env}_{hjt} + N^{NonEnv}_{hjt}$. We use the transformation $R^g_{hjt} = \ln(1 + N^g_{hjt})$, which retains cells with no notification. Counts measure regulatory exposure rather than legal stringency or actual compliance expenditure. The regression tables use these log-one-plus stocks and their environmental and non-environmental components.

The positive-flow sample provides information on the log unit value, demand-revealed quality, quality-adjusted price, log export value, and log physical volume. Given that no physical quantity is provided to calculate unit values in some cases, the corresponding IV value sample is larger than the common price–quality and volume sample. To study inactive relationships, we construct a panel of firm–product–destination combinations with at least one observed positive export flow over the sample period. We extend each combination to all years in the panel, assigning zero export value ($X_{fhjt} = 0$) and zero physical volume to non-export years.

To define entry and exit indicators, set $I_{fhjt} = \mathbf{1}\{X_{fhjt} > 0\}$. For observations with observed export status in the preceding year, we define entry and exit, respectively, as

$$Entry_{fhjt} = I_{fhjt}(1 - I_{fhj,t-1}), \qquad Exit_{fhjt} = (1 - I_{fhjt})I_{fhj,t-1}. \tag{4}$$

Because the data include relationships that exported at least once during the sample period, the estimated transitions apply to this ever-exporting panel. They do not measure the probability of entering every conceivable product–destination market.

3.4 Estimating equations and fixed effects

For each outcome y (value, volume, unit value, quality, and quality-adjusted price), the reduced forms that are estimated are, respectively,

$$y_{fhjt} = \beta_T R^{TBT}_{hjt} + \boldsymbol{\gamma}'\mathbf{X}_{ft} + \beta_\tau \ln(1 + \text{Tariff}_{hjt}) + \alpha_f + \alpha_{hj} + \alpha_{jt} + \varepsilon_{fhjt}, \tag{5}$$

$$y_{fhjt} = \beta_E R^{Env}_{hjt} + \beta_N R^{NonEnv}_{hjt} + \boldsymbol{\gamma}'\mathbf{X}_{ft} + \beta_\tau \ln(1 + \text{Tariff}_{hjt}) + \alpha_f + \alpha_{hj} + \alpha_{jt} + \varepsilon_{fhjt}. \tag{6}$$

The vector $\mathbf{X}_{ft}$ contains the firm characteristics: log employment, the high-skilled (ISCED 5–8) employment share in total employment (expressed as a percentage), log physical capital per worker, log software capital per worker, TFP, and log patent stock per worker. TFP is measured by the productivity index ω recovered using the estimator of Ackerberg et al. (2015). Output and inputs are transformed using the inverse hyperbolic sine before estimating productivity. Firm fixed effects absorb persistent firm attributes, product–destination fixed effects absorb persistent market–product conditions, and destination–year fixed effects absorb destination-wide annual shocks.

Conditional positive-flow results and zero-inclusive estimates answer different questions. Writing r for positive export value and $\mathcal{F}$ for conditioning information gives

$$\mathbb{E}[X_{fhjt} \mid \mathcal{F}] = \Pr(I_{fhjt} = 1 \mid \mathcal{F})\mathbb{E}[r_{fhjt} \mid I_{fhjt} = 1, \mathcal{F}]. \tag{7}$$

Consequently, a positive coefficient conditional on active exports can coexist with a negative coefficient on value including zeros. In this paper, market access refers to participation and recorded relationship transitions; zero-inclusive trade refers to the conditional mean of value or volume in the expanded ever-exporting panel. Neither measure is an estimate of economy-wide aggregate trade, and changes in value do not establish changes in physical quantities. Because entry and exit are defined in the full relationship panel, their coefficients describe unconditional transition incidence within that panel rather than entry hazards conditional on previous inactivity or exit hazards conditional on previous activity. Results from different samples and estimators do not supply an exact empirical decomposition of these channels. Moreover, $\ln p = \ln \widehat{\mathcal{Z}} + \ln \widetilde{p}$ is an accounting identity. Its regression coefficients add when the three outcomes use the same sample and the same linear estimation mapping, including a common IV weighting matrix where applicable. The one-stage coefficients approximately satisfy this restriction. In two-step IV-GMM, however, the estimated weighting matrix can differ across outcomes, so coefficient additivity need not hold even when the samples, regressors, and instruments coincide.[2]

3.5 Endogeneity and instrumental variables

Regulatory stocks may be endogenous to export performance. Destinations may adopt or tighten requirements in response to import growth, product incidents, lobbying, or unobserved changes in demand. Reverse causality, measurement error, and omitted variables may therefore bias the estimates of Equations (5) and (6). High-dimensional fixed effects absorb unobserved heterogeneity at the specified levels, but they do not eliminate all potential sources of endogeneity. We therefore complement these controls with an IV strategy.

For each regulatory category, we use two excluded instruments: the log of one plus the leave-destination-out worldwide mean of the relevant TBT stock for a product, and the log

[2]Let $A_W = (D'ZWZ'D)^{-1}D'ZWZ'$ be the common linear IV-GMM mapping after partialling out the fixed effects, where D is the regressor matrix and Z the instrument matrix. Since $y_p = y_{\mathcal{Z}} + y_{\widetilde{p}}$ observation by observation, $A_W y_p = A_W y_{\mathcal{Z}} + A_W y_{\widetilde{p}}$. Separately estimated outcome-specific matrices W_p, $W_{\mathcal{Z}}$, and $W_{\widetilde{p}}$ need not yield this equality. A common-sample two-stage least squares (2SLS) or common-weight GMM re-estimation is the appropriate coefficient-additivity check; the explanation in itself does not verify the underlying data identity or the estimation implementation.

of one plus the own-destination mean across other products. These instruments capture regulatory developments outside the destination–product cell under consideration. The total-stock specification instruments R^{TBT}_{hjt} using the two total-TBT instruments. The category-specific specification jointly instruments R^{Env}_{hjt} and R^{NonEnv}_{hjt} using the four corresponding environmental and non-environmental instruments. For compactness, let $\mathcal{G} = \{TBT\}$ in the total-stock specification and $\mathcal{G} = \{Env, NonEnv\}$ in the category-specific specification. Let $\mathbf{Z}_{hjt}$ collect the excluded instruments, and let $\mathbf{C}_{fhjt}$ collect the firm controls and $\ln(1 + \text{Tariff}_{hjt})$.

IV-GMM estimation of continuous outcomes, entry, and exit. For each endogenous regulatory variable $g \in \mathcal{G}$, the first-stage equation is

$$R^g_{hjt} = \mathbf{Z}'_{hjt}\boldsymbol{\pi}_g + \mathbf{C}'_{fhjt}\boldsymbol{\delta}_g + a^g_f + a^g_{hj} + a^g_{jt} + v^g_{fhjt}. \tag{8}$$

Each first stage includes the full set of excluded instruments, the included controls, and the same fixed-effect structure – namely, a^g_f, a^g_{hj}, and a^g_{jt} – as the corresponding outcome equation with error term v^g_{fhjt}. Although regulatory exposure varies at the destination–product–year level, its fitted value also reflects the firm controls and firm fixed effects.

The structural outcome equation is

$$y^m_{fhjt} = \sum_{g\in\mathcal{G}} \beta^m_g R^g_{hjt} + \mathbf{C}'_{fhjt}\boldsymbol{\gamma}_m + \alpha^m_f + \alpha^m_{hj} + \alpha^m_{jt} + \varepsilon^m_{fhjt}, \tag{9}$$

where

$$y^m_{fhjt} \in \left\{\ln p_{fhjt}, \ln \widehat{\mathcal{Z}}_{fhjt}, \ln \widetilde{p}_{fhjt}\right\}.$$

These price and quality outcomes are estimated on observations with positive exports and the information required to construct the relevant dependent variable. For the participation specifications, the same structural equation is used with $y^m_{fhjt} \in \{Entry_{fhjt}, Exit_{fhjt}\}$ in the expanded ever-exporting relationship panel.

The 2SLS representation clarifies how the instruments isolate variation in regulatory exposure before the GMM weighting step. Let $\widehat{R}^g_{fhjt}$ denote the fitted value from Equation (8). The corresponding second-stage regression is

$$y^m_{fhjt} = \sum_{g\in\mathcal{G}} \beta^m_g \widehat{R}^g_{fhjt} + \mathbf{C}'_{fhjt}\boldsymbol{\gamma}_m + \alpha^m_f + \alpha^m_{hj} + \alpha^m_{jt} + e^m_{fhjt}. \tag{10}$$

Inference is obtained from the IV estimator rather than from ordinary least squares (OLS) standard errors applied to this fitted-regressor representation.

The reported continuous-outcome and participation estimates use two-step linear IV generalised method of moments (GMM), implemented with the `gmm2s` option in `ivreghdfe`. The estimator starts from the 2SLS moment conditions and updates the weighting matrix using first-step residuals, allowing for heteroskedasticity and dependence within destination–product clusters. The GMM weighting step therefore applies to the unit-value, quality, quality-adjusted-price, export-value, export-volume, entry, and exit equations alike. Standard errors are clustered

by destination–product.

The additional continuous outcomes include log-one-plus export value and volume in the panel containing zero flows. For the binary entry and exit indicators, IV-GMM estimates a linear probability model. Under instrument validity, its coefficients describe changes in the probability of the recorded transition per log-point increase in one plus the regulatory stock within the ever-exporting relationship panel. They are not proportional changes in the transition probability. The one-stage Probit specifications in the Appendix provide complementary evidence on participation. All linear IV-GMM specifications absorb firm, product–destination, and destination–year fixed effects. The robustness specifications in Tables B.4 and B.5 additionally absorb product–year fixed effects in both the first-stage and outcome equations.

Poisson control-function estimation of export value and volume. For export value and physical volume in levels, including zero flows, we use Stata's `ivpoisson cfunction` estimator. To accommodate the large fixed-effect structure, we follow the computational approach described by Artuso et al. (2026), obtaining fixed-effect predictions from a preliminary PPML regression and including them as controls in the subsequent IV estimation. The procedure can be described in three steps.

Step 1: Obtain fixed-effect predictions from PPML. We first estimate an auxiliary PPML model of export value, including zero observations, on tariffs and the fixed effects:

$$\mu^{(0)}_{fhjt} = \exp\left[b^{(0)}_{\tau} \ln(1 + \text{Tariff}_{hjt}) + a^{(0)}_{f} + a^{(0)}_{hj} + a^{(0)}_{jt}\right], \tag{11}$$

where $\mu^{(0)}_{fhjt}$ is the modelled conditional mean of X_{fhjt}, the export value of firm f of product h to destination j at time t. We retain the estimated fixed-effect components as

$$\widehat{\mathbf{F}}_{fhjt} = \left(\widehat{a}^{(0)}_{f}, \widehat{a}^{(0)}_{hj}, \widehat{a}^{(0)}_{jt}\right)'. \tag{12}$$

Step 2: Model regulatory exposure and recover first-stage residuals. For each endogenous regulatory component, the linear reduced form includes the excluded instruments, the controls, and the fixed-effect predictions:

$$R^{g}_{hjt} = c_g + \mathbf{Z}'_{hjt}\boldsymbol{\pi}_g + \mathbf{C}'_{fhjt}\boldsymbol{\delta}_g + \widehat{\mathbf{F}}'_{fhjt}\boldsymbol{\kappa}_g + v^{g}_{fhjt}, \qquad g \in \mathcal{G}. \tag{13}$$

The associated residual is

$$\widehat{v}^{g}_{fhjt} = R^{g}_{hjt} - \left(\widehat{c}_g + \mathbf{Z}'_{hjt}\widehat{\boldsymbol{\pi}}_g + \mathbf{C}'_{fhjt}\widehat{\boldsymbol{\delta}}_g + \widehat{\mathbf{F}}'_{fhjt}\widehat{\boldsymbol{\kappa}}_g\right). \tag{14}$$

Step 3: Estimate the export equation with the control function. For $Y_{fhjt} \in \{X_{fhjt}, q_{fhjt}\}$, the exponential conditional-mean specification is

$$\mu^{Y}_{fhjt} = \exp\left[c_Y + \sum_{g\in\mathcal{G}} \beta^{Y}_{g} R^{g}_{hjt} + \mathbf{C}'_{fhjt}\boldsymbol{\gamma}_Y + \widehat{\mathbf{F}}'_{fhjt}\boldsymbol{\lambda}_Y + \sum_{g\in\mathcal{G}} \rho^{Y}_{g} \widehat{v}^{g}_{fhjt}\right]. \tag{15}$$

Here, μ^{Y}_{fhjt} denotes the modelled conditional mean of export value or volume. The outcome equation retains observed regulatory exposure and includes one residual for each endogenous regulatory component. The residual terms account for endogeneity under the maintained control-function assumptions.

Equations (13)–(15) describe the control-function logic. Stata's `ivpoisson cfunction` implements this logic through joint estimation of the reduced-form and outcome moment conditions. Consequently, the implementation is not simply a PPML regression with manually inserted residuals.

The saved fixed effects enter as generated covariates with estimated coefficients. This provides a tractable way to incorporate the preliminary fixed-effect predictions, but it is not equivalent to absorbing unrestricted fixed effects directly in the nonlinear IV model. In particular, the auxiliary regression excludes regulatory exposure and the firm controls, so its fixed-effect estimates need not coincide with those from the full structural specification. Standard errors are clustered by destination–product.

The IV specifications are presented as benchmark specifications in Tables 2 and 3. Their identifying assumption is that, conditional on the controls and fixed effects, regulatory developments affecting the same product in other destinations or other products in the same destination influence Austrian exports to cell hjt only through that cell's regulatory exposure. The instruments are intended to capture regulatory diffusion and destination-wide regulatory capacity while excluding the destination–product observation itself.

We report Kleibergen–Paap statistics and Hansen overidentification tests for the linear IV specifications. These diagnostics do not automatically apply to the nonlinear estimates. Strong first-stage relationships establish relevance, but they do not establish exclusion. Likewise, failure to reject the Hansen test does not prove instrument validity. In Table 2, Hansen tests reject at 5% for positive export value, full-panel log-one-plus volume, and exit; the quality-adjusted-price equation additionally rejects at 10%. Thus, the total-stock benchmark also has outcome-specific identification limitations. In Table 3, every reported linear equation rejects at 5%. These rejections concern the joint moment restrictions and may reflect instrument invalidity or specification error; they do not identify which instrument fails. The category-specific estimates are therefore suggestive conditional patterns, and economically plausible coefficient signs do not establish their causal validity. The absence of a reported nonlinear overidentification test does not validate the IV Poisson estimates.

A further mechanical feature of simple leave-one-out averages, and its interaction with the fixed effects, is set out in Appendix A.1; a high first-stage statistic cannot distinguish this feature from a valid external regulatory shock.

3.6 Robustness checks and additional specifications

We conduct four sets of robustness checks to assess the sensitivity of the benchmark results to the estimation method, the fixed-effect structure, and the composition of the estimation sample. Each exercise considers both the overall destination TBT stock and the separate environmental

and non-environmental components using the relevant price, quality, export value, export volume, and market-participation outcomes. Throughout these specifications, regulatory exposure is measured by stocks of destination-market TBT notifications. Home-country regulatory stocks are reported descriptively in Table B.1, but their direct effects are not separately estimated.

First, Appendix Tables B.2 and B.3 report one-stage estimates without instrumenting TBT exposure, providing a comparison with the benchmark IV specifications. For continuous outcomes conditional on positive export flows, we estimate high-dimensional fixed-effects linear models. Entry and exit are examined using Probit models, while export value and physical volume in levels, including zero flows, are estimated using PPML (Santos Silva and Tenreyro 2006; Correia et al. 2019a; Correia et al. 2019b). The linear and PPML specifications absorb firm, product–destination, and destination–year fixed effects. The Probit models instead include generated fixed-effect predictions from preliminary PPML estimations as covariates, which is not equivalent to absorbing those effects directly in the Probit likelihood. Probit coefficients represent changes in the latent index rather than probability changes in percentage points, and PPML coefficients refer to the log conditional mean of export value or volume. These estimates therefore provide alternative conditional associations rather than directly comparable causal estimates.

Second, Appendix Tables B.4 and B.5 extend the benchmark IV specifications by additionally controlling for product–year fixed effects. These absorb shocks common to Austrian exporters of the same product in a given year, including changes in home-country product regulations, international technological developments, and other product-specific demand or supply shocks shared across destinations. In the linear IV specifications, product–year effects are included in both the first-stage and outcome equations; the nonlinear IV Poisson specifications retain the generated fixed-effect approach described above. This exercise examines whether the estimated associations with destination-market TBT exposure persist after accounting for common product–year variation. However, these fixed effects do not separately identify the impact of home regulations and cannot absorb heterogeneous firm-level responses to them.

Third, Appendix Tables B.6 and B.7 restrict the estimation sample to destinations outside the European Union. In the benchmark data, bilateral tariffs and measured destination TBT exposure are set to zero for intra-EU trade relationships, reflecting the maintained empirical convention for trade within the single market rather than the absence of common EU technical requirements. The extra-EU specifications therefore assess whether the benchmark results are sensitive to the inclusion of these zero-coded observations and whether the estimated relationships persist when identification is restricted to variation in regulatory exposure across non-EU export markets.

Fourth, Appendix Tables B.8 and B.9 restrict the sample to products classified as environmental goods, using the product list described in Section 3.1. This exercise examines whether the estimated relationships between TBT exposure and firms' export outcomes differ within a set of products associated with environmental technologies and activities. As in the other robustness exercises, we consider both total TBT exposure and its environmental and non-environmental components, distinguishing price and quality adjustments among active exporters from changes

in export value, physical volume, and participation.

Finally, Appendix Tables B.10–B.15 provide complementary evidence on heterogeneity in the association between total destination TBT exposure and firms' export outcomes. These one-stage specifications interact regulatory exposure separately with employment, skill intensity, physical capital intensity, software capital intensity, total factor productivity, and patent intensity, as described below. We examine whether the association with total destination TBT exposure varies with firm characteristics. Let C_{ft} denote, in turn, log employment, the high-skilled employment share in percentage points, log physical capital per worker, log software capital per worker, TFP in the reported table units, or log patent stock per worker. Each characteristic enters a separate one-stage interaction specification:

$$\begin{aligned}\eta^m_{fhjt} = \beta^m_R R^{TBT}_{hjt} + \beta^m_C C_{ft} + \beta^m_{RC} R^{TBT}_{hjt} C_{ft} + \boldsymbol{\gamma}'_m \mathbf{X}^{(-C)}_{ft} \\ + \beta^m_\tau \ln(1 + \text{Tariff}_{hjt}) + \mathcal{A}^m_{fhjt},\end{aligned} \tag{16}$$

where $\mathbf{X}^{(-C)}_{ft}$ contains the remaining firm controls. For OLS, η^m is the conditional mean of the logged outcome; for PPML, it is the log conditional mean of value or volume; and for Probit, it is the latent index. The term $\mathcal{A}^m$ contains absorbed firm, product–destination, and destination–year effects for OLS and PPML and generated effect predictors for Probit. None of the three terms (the exposure, the characteristic, or their interaction) is instrumented in these specifications. For OLS and the PPML log mean, the regulatory slope is $\beta^m_R + \beta^m_{RC} C_{ft}$, so the interaction describes conditional moderation rather than a structural mechanism or a causal return to capability investment. For Probit, probability effects additionally depend on the normal density evaluated at the full index; the sign of β^m_{RC} alone is not the sign of a probability interaction. The main exposure coefficient is evaluated at $C_{ft} = 0$, which need not be representative. The interactions concern total TBT stocks and do not establish environmental-category-specific moderation.

Across all robustness exercises, standard errors are clustered by destination–product to allow for correlated disturbances across firms and years within the same regulated product market. The robustness checks assess the stability of the estimated associations but do not, by themselves, establish the validity of the instruments. In particular, international diffusion of standards may reflect common technological developments, product-demand shocks, safety concerns, or input–output linkages that directly affect Austrian exports (Rocha and Thakur 2026). Although destination–year and product–year fixed effects address some of these common shocks, the exclusion restriction remains a maintained identifying assumption. The robustness results are discussed in Section 4.4 and the interaction results in Section 4.5.

4 Results and discussion

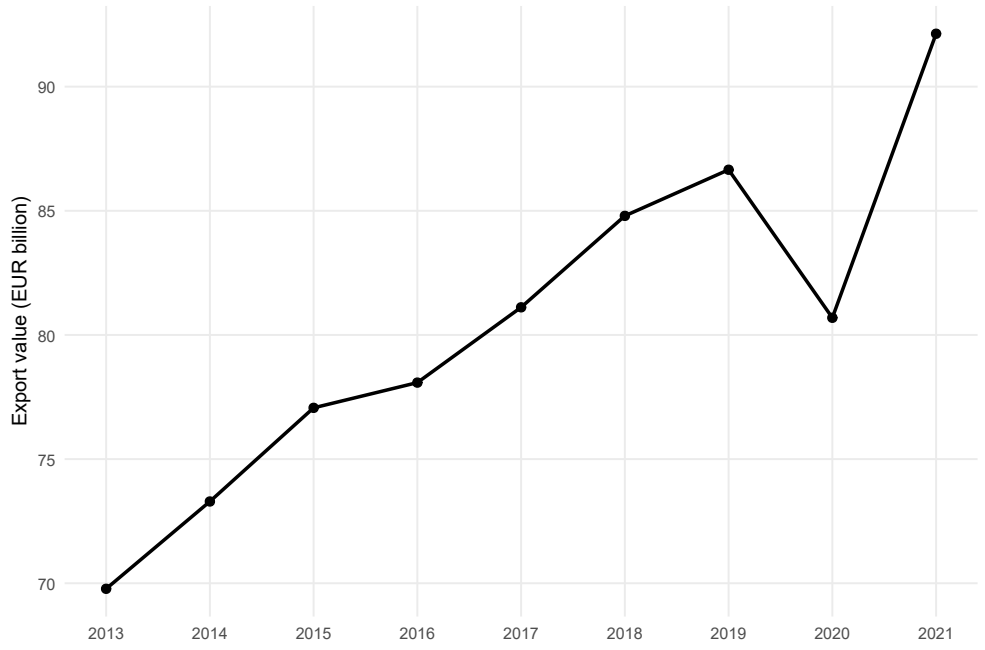
This section first documents export and regulatory trends before interpreting the benchmark IV estimates. One-stage comparisons, alternative samples and fixed effects, and firm interactions assess the consistency and heterogeneity of the findings. The central distinction is between quality and sales within active export flows and trade and transitions in the expanded relationship panel. The estimates concern destination TBT notification stocks. In the robustness specifications,

product–year fixed effects absorb additive effects shared across Austrian exporters of the same product and year, including common home-regulatory changes, but not heterogeneous responses to those requirements.

4.1 Descriptive evidence

Figure 1 shows that exports in the manufacturing estimation sample rose from approximately EUR 70 billion in 2013 to more than EUR 92 billion in 2021. The increase was broad and persistent through 2019, interrupted by a marked contraction in 2020 during the COVID-19 pandemic, and followed by a strong rebound in 2021. This time profile matters for the regressions because it confirms that the sample spans both a prolonged expansion and a major common shock. Destination–year fixed effects absorb common destination-specific shocks, while the robustness specifications additionally include product–year fixed effects to absorb common product-specific shocks, so the estimated TBT coefficients are not identified from these broad annual shocks.

Figure 1: Annual value of Austrian manufacturing exports

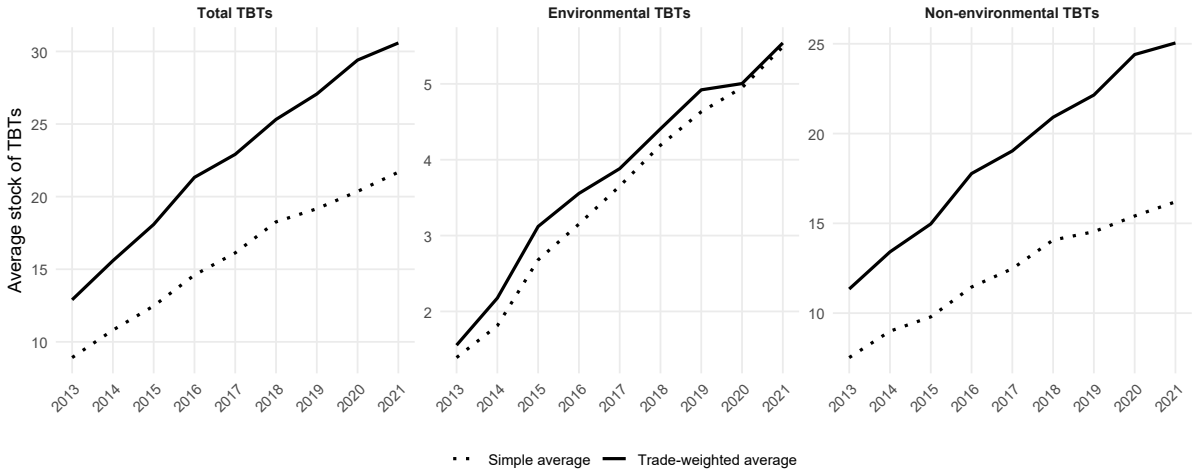


Notes: The figure reports the annual value of Austrian manufacturing exports, obtained by aggregating the export flows in the estimation sample used in the empirical analysis.

Figure 2 documents a pronounced increase in destination-market notification exposure in the positive-flow sample. Appendix Figure B.1 shows the corresponding series for the full sample, including zero export flows. In destination markets, the trade-weighted mean stock of total TBTs more than doubled over the sample period, from roughly 13 to around 30 notifications. Most of this increase reflects non-environmental measures, but the stock of environmental TBTs also rose steadily, from around 1.5 to more than 5. The trade-weighted series generally lies above the simple average, particularly for total and non-environmental TBTs. Austrian exports are therefore disproportionately directed towards product–destination cells with more intensive technical regulation. This pattern may reflect demand for regulated, higher-quality goods, the

concentration of Austrian exports in advanced markets, or firms' endogenous selection into regulated destinations; it should not be interpreted causally.

Figure 2: Destination-country TBT stocks over time



Notes: The figure reports annual simple and export-value-weighted averages of the cumulative stocks of total, environmental, and non-environmental TBTs imposed by destination countries. The calculations are based on the intensive-margin sample. Export-value-weighted averages are calculated using firm-level export values as weights.

Appendix Table B.1 reports destination stocks for the positive-flow and expanded panels. The mean destination total is 16.8 TBTs in the positive-flow sample, including 3.9 environmental TBTs, and 13.6 in the expanded panel, including 3.1 environmental TBTs. The smaller full-panel mean is consistent with selection into more regulated destinations among active relationships. Descriptive counts cannot distinguish a stricter rule from a greater number of notifications or reveal actual environmental outcomes.

4.2 Results of benchmark IV estimates

Table 2 contains the IV estimates for total destination TBT exposure. The linear IV columns for active flows show a unit-value coefficient of 0.0416 and quality coefficient of 0.0514, both significant at 1%. The quality-adjusted-price coefficient is −0.00818 and significant at 10%. These results suggest that, in the variation predicted by the instruments, observed unit values and demand-revealed quality move together and the price net of quality declines modestly. A 10% increase in one plus the stock is associated with approximately 0.51% higher measured quality, 0.42% higher unit value, and 0.08% lower quality-adjusted price. These are local IV associations under the exclusion restriction, not an experimental effect of a specific environmental rule. The sum ($0.0514 - 0.00818 = 0.04322$) differs from the reported unit-value coefficient (0.0416) by 0.00162. Separate two-step GMM equations can generate such differences because their moment weighting matrices depend on outcome-specific residuals. The coefficient difference therefore does not, by itself, establish an inconsistency in the underlying price–quality identity. The Hansen p-values for unit value and quality do not reject the reported overidentifying restrictions, but they do reject them at the 10% level of significance for quality-adjusted price.

The positive-flow export-value coefficient is positive (significant at 5%), whereas the positive-volume coefficient is negative and statistically insignificant. The value column uses 3.78 million observations, compared with 3.31 million for the outcomes requiring quantity and a unit value; thus, the difference between the two coefficients is not an exact within-sample price–quantity decomposition. In the expanded relationship panel, linear IV-GMM using $\ln(1 + \text{value})$ produces a coefficient of 0.191 and $\ln(1 + \text{volume})$ one of 0.0779. These transformations weight small positive and zero flows differently from PPML, so their apparent agreement with positive-flow value is not evidence of an aggregate export increase.

Taken together, the positive-flow estimates associate greater total TBT exposure with higher demand-revealed quality and active export value. The negative quality-adjusted-price coefficient is significant only at 10%, and the Hansen tests for this equation and active export value require the outcome-specific caution discussed in Section 3.5. Several explanations are consistent with this pattern, including quality adjustment, greater buyer confidence in product attributes, selection, and changes in the product's appeal in the destination market. The estimates cannot distinguish among these explanations. The statistically insignificant physical-volume estimate does not establish an increase in quantities demanded.

Interpretation in relation to the literature. The quality associations are consistent with earlier evidence linking technical regulation to the quality of traded products (Ghodsi and Stehrer 2022; Disdier, Gaigné, et al. 2023). The latter study also highlights product-quality information and exporter selection. These provide possible interpretations of the Austrian results, but the estimates do not distinguish improvements in physical attributes from changes in buyer perceptions, unobserved demand or delivered costs, or the composition of active export relationships. The accompanying rise in unit values therefore cannot be read solely as higher compliance costs, and a lower quality-adjusted price does not isolate an information or certification effect.

However, the nonlinear IV Poisson columns show a positive coefficient for export value that is not statistically significant as well as a negative coefficient for export volume that is significant at 1%. This is a substantive asymmetry: the reported zero-inclusive *value* estimate is not statistically distinguishable from zero, while the physical-volume response is negative in that specification. The Poisson setup uses predicted fixed-effect components rather than absorbed effects in the final `ivpoisson` call; its coefficient is also not directly comparable with the linear $\ln(1 + \text{value})$ coefficient. Neither a significant positive nor a robust negative zero-inclusive value association follows from the results reported in Table 2.

In the participation columns, the two-step IV-GMM exit coefficient is positive but statistically insignificant, whereas the entry coefficient is positive and significant at the 1% level. A 10% increase in one plus the total TBT stock is associated with an entry probability approximately 0.0835 percentage points higher within the ever-exporting relationship panel. This estimate concerns the probability of a recorded transition, not a proportional change in entry or entry into every conceivable export market. The Hansen test does not reject the overidentifying restrictions for the entry equation, but it does reject them for the exit equation, raising an exclusion concern for the latter. Non-rejection for entry does not establish instrument validity.

Moreover, the positive entry association loses significance when product–year effects are added. Table 2 therefore provides more stable evidence of quality upgrading among active exporters than of a general expansion in market access.

Table 2: Benchmark IV estimates: overall destination TBT stock

	Linear IV-GMM outcomes							IV Poisson outcomes		Participation outcomes	
	Unit value (1)	Quality (2)	Q-adjusted price (3)	Positive value (4)	Positive volume (5)	ln(1+ value) (6)	ln(1+ volume) (7)	Value (8)	Volume (9)	IV-GMM exit (10)	IV-GMM entry (11)
Endogenous regulatory variable											
$\ln(1+TBT_{hjt})$	0.0416***	0.0514***	−0.00818*	0.0309**	−0.0128	0.191***	0.0779***	0.00331	−0.0523***	0.000617	0.00876***
	(0.00670)	(0.00913)	(0.00423)	(0.0132)	(0.0127)	(0.0166)	(0.0124)	(0.00397)	(0.0168)	(0.00100)	(0.00127)
Observed controls											
$\ln(1+\text{Tariff}_{hjt})$	−0.00633	−0.00910	0.00260	−0.0132*	−0.00266	−0.0449***	−0.0403***	0.0206***	−0.197***	−0.000631	−0.00132
	(0.00443)	(0.00565)	(0.00252)	(0.00749)	(0.00773)	(0.0174)	(0.0132)	(0.00416)	(0.0287)	(0.000655)	(0.00104)
$\ln(Emp_{ft})$	−0.0303***	0.0273***	−0.0575***	0.186***	0.202***	1.261***	0.668***	−0.0632***	−0.249***	0.0420***	0.0746***
	(0.00507)	(0.00653)	(0.00322)	(0.00963)	(0.00997)	(0.00781)	(0.00550)	(0.00341)	(0.0205)	(0.000627)	(0.000673)
$Skill_{ft}$	0.000526*	−0.0000400	0.000572***	−0.00239***	−0.00224***	−0.00554***	−0.00275***	0.00503***	−0.00731	−0.000389***	−0.000118***
	(0.000286)	(0.000372)	(0.000177)	(0.000527)	(0.000536)	(0.000383)	(0.000224)	(0.000464)	(0.00541)	(3.80×10^{-5})	(4.12×10^{-5})
$\ln(K/L)_{ft}$	0.00153**	0.00468***	−0.00312***	0.00917***	0.00790***	0.0148***	0.00780***	0.0352***	0.373***	−0.000116	0.000703***
	(0.000750)	(0.000954)	(0.000458)	(0.00137)	(0.00143)	(0.00121)	(0.000756)	(0.00331)	(0.0242)	(0.000131)	(0.000140)
$\ln(Software/L)_{ft}$	−0.00524**	−0.00737***	0.00209	−0.00211	−0.00104	0.0234***	0.00545***	0.0148*	−0.488***	−0.00481***	0.00591***
	(0.00206)	(0.00264)	(0.00128)	(0.00385)	(0.00397)	(0.00342)	(0.00204)	(0.00899)	(0.0344)	(0.000381)	(0.000408)
TFP_{ft}	0.000540***	0.00135***	−0.000803***	0.00184***	0.00188***	0.00269***	0.00216***	−0.00968***	−0.0166***	−0.000408***	-3.40×10^{-5}
	(0.000193)	(0.000249)	(0.000124)	(0.000372)	(0.000383)	(0.000348)	(0.000245)	(0.000782)	(0.00613)	(4.26×10^{-5})	(4.04×10^{-5})
$\ln(Patent/L)_{ft}$	−0.124***	−0.117***	−0.00671	0.178***	0.143***	0.0319	0.163***	−0.134***	−0.405***	−0.0146***	−0.0223***
	(0.0242)	(0.0307)	(0.0138)	(0.0405)	(0.0423)	(0.0336)	(0.0192)	(0.0149)	(0.0937)	(0.00283)	(0.00312)
Auxiliary predictor	–	–	–	–	–	–	–	−0.0797***	−0.120***	–	–
								(0.00882)	(0.0444)		
Observations	3,307,996	3,307,996	3,307,996	3,783,565	3,307,996	11,043,888	11,043,888	11,029,145	11,029,145	11,043,888	11,043,888
Hansen J	0.733	2.488	3.658	5.660	2.209	2.603	18.89	–	–	10.24	0.182
Hansen p-value	0.392	0.115	0.0558	0.0174	0.137	0.107	1.38×10^{-5}	–	–	0.00137	0.669
Cragg–Donald	1.094×10^{6}	1.094×10^{6}	1.094×10^{6}	1.183×10^{6}	1.094×10^{6}	3.372×10^{6}	3.372×10^{6}	–	–	3.372×10^{6}	3.372×10^{6}
Kleibergen–Paap	4,700	4,700	4,700	4,542	4,700	5,963	5,963	–	–	5,963	5,963
Firm, destination–product, destination–year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Generated	Generated	Yes	Yes

Notes: Each column is a separate regression. The table reports observed controls for the displayed outcome columns. The high-skilled share is in percentage points and TFP enters in levels; employment, capital per worker, software per worker, patents per worker, and one plus the bilateral tariff enter in logs. Columns (1)–(7) are two-step linear IV-GMM models, columns (8)–(9) are IV Poisson models, and columns (10)–(11) are two-step IV-GMM linear probability models for exit and entry, respectively. Only the TBT stock is instrumented, so control coefficients are conditional within-firm associations rather than causal effects. Standard errors are clustered by destination–product. $^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.10$.

Table 3 enters environmental and non-environmental stocks jointly. Environmental TBTs are positively associated with demand-revealed quality and unit values and negatively associated with quality-adjusted prices. These are suggestive associations: the Hansen tests reject the joint moment restrictions in every reported linear column of this category-specific benchmark. The positive-flow value coefficient is positive and statistically significant at 1%, while the corresponding physical-volume estimate is also positive but statistically insignificant. In the full-panel linear ln(1 + volume) model, however, the coefficient is negative and significant, while the log-one-plus value coefficient is positive but statistically insignificant. This underlines how the apparent response varies with the outcome and the relative weighting of small and zero flows.

Non-environmental TBTs are positively associated with unit values and quality-adjusted prices; both coefficients are significant at the 5% level. The estimated quality coefficient is not statistically significant. Among positive export flows, the value and volume coefficients are negative and significant at the 5% level. By contrast, the full-panel ln(1 + value) and ln(1 + volume) coefficients are positive and statistically significant. These positive full-panel estimates do not establish wider market access: the estimands and samples differ, and the overidentification tests reject for these equations. Taken together, the estimates suggest higher observed prices but lower sales in existing flows, alongside a different pattern across the expanded relationship panel. They do not identify the contribution of entry, exit, or changes in the size of other relationships to that difference.

For environmental TBTs, the IV Poisson export-value coefficient is negative and significant at the 1% level, whereas the full-panel linear ln(1 + value) coefficient is positive but statistically insignificant. The non-environmental value coefficient is positive and significant at the 1% level in both specifications. A 10% increase in $1 + N^{Env}$ corresponds to approximately 0.30% lower zero-inclusive export value in the IV Poisson specification. By contrast, the environmental coefficient for value among positive export flows is positive and significant at the 1% level. Environmental TBTs also have negative and significant physical-volume coefficients in both the full-panel linear IV and IV Poisson models; the non-environmental IV Poisson volume coefficient is statistically insignificant. Thus, the two zero-inclusive specifications agree on a negative environmental-volume association but yield different estimates for export value. Differences across these estimates may reflect participation, composition, and the distinct samples and functional forms; they do not identify how much each channel contributes.

Taken together, the benchmark estimates associate environmental TBTs with higher export quality, lower quality-adjusted prices, and higher export value among active Austrian export relationships. However, the zero-inclusive IV Poisson estimates indicate lower export value and volume. Non-environmental TBTs have no statistically detectable quality association but are associated with higher unit values and quality-adjusted prices. Their value and volume coefficients are negative among positive flows but positive in the full-panel log-one-plus equations; IV Poisson value is positive, while volume is statistically insignificant. The trade associations therefore depend on the sample and specification.

The IV-GMM participation estimates indicate positive associations of non-environmental TBTs with both exit and entry, significant at the 1% level. This combination is consistent

with more frequent transitions in both directions rather than an unambiguous improvement in survival or net participation. Environmental TBTs have a negative exit coefficient, significant at the 1% level, while their entry coefficient is statistically insignificant. This describes lower recorded exit incidence within the ever-exporting panel, without statistically significant evidence of additional entry. It is not an estimate of the exit hazard conditional on prior exporting. The Hansen tests reject the overidentifying restrictions in both participation equations, so neither this pattern nor the non-environmental transition pattern establishes a causal market-access effect.

Active exports and market participation. The differences between active-flow and zero-inclusive estimates motivate examining participation and sales separately. The standards literature documents heterogeneous responses across exporters and across these margins (Fontagné et al. 2015; Disdier, Gaigné, et al. 2023), while sunk export costs help explain why entry and continuation can respond differently (Roberts and Tybout 1997). However, the Austrian estimates do not provide an accounting decomposition of these responses. The positive-flow sample includes entrants as well as continuing exporters; samples, transformations, and estimators differ across outcomes; and the participation equations measure transition incidence within the ever-exporting panel. The environmental benchmark therefore does not establish that participation losses cause the contrast between positive active-value and negative IV Poisson value coefficients. The category-specific overidentification rejections further limit causal interpretation.

Table 3: Benchmark IV estimates: environmental and non-environmental TBT stocks

	Linear IV-GMM outcomes							IV Poisson outcomes		Participation outcomes	
	Unit value (1)	Quality (2)	Q-adjusted price (3)	Positive value (4)	Positive volume (5)	ln(1+ value) (6)	ln(1+ volume) (7)	Value (8)	Volume (9)	IV-GMM exit (10)	IV-GMM entry (11)
Endogenous regulatory variables											
$\ln(1 + NonEnvTBT_{hjt})$	0.0204**	0.00775	0.0116**	−0.0343**	−0.0350**	0.203***	0.102***	0.0184***	−0.0204	0.00350***	0.0114***
	(0.00855)	(0.0116)	(0.00545)	(0.0169)	(0.0167)	(0.0175)	(0.0125)	(0.00670)	(0.0174)	(0.00118)	(0.00163)
$\ln(1 + EnvTBT_{hjt})$	0.0284***	0.0478***	−0.0182***	0.0590***	0.0173	0.0258	−0.0342***	−0.0305***	−0.0595**	−0.00310***	−0.00132
	(0.00761)	(0.00973)	(0.00440)	(0.0132)	(0.0135)	(0.0180)	(0.0130)	(0.00864)	(0.0250)	(0.00109)	(0.00129)
Observed controls											
$\ln(1 + \text{Tariff}_{hjt})$	−0.00775*	−0.0101*	0.00204	−0.0115	−0.000583	−0.0613***	−0.0489***	0.0184***	−0.183***	−0.000496	−0.00248**
	(0.00445)	(0.00565)	(0.00249)	(0.00740)	(0.00764)	(0.0163)	(0.0122)	(0.00415)	(0.0233)	(0.000648)	(0.00101)
$\ln(Emp_{ft})$	−0.0307***	0.0269***	−0.0575***	0.185***	0.202***	1.260***	0.668***	−0.0631***	−0.250***	0.0420***	0.0747***
	(0.00507)	(0.00653)	(0.00322)	(0.00963)	(0.00997)	(0.00781)	(0.00550)	(0.00341)	(0.0197)	(0.000627)	(0.000673)
$Skill_{ft}$	0.000494*	−0.000102	0.000587***	−0.00240***	−0.00227***	−0.00556***	−0.00279***	0.00510***	−0.00701	−0.000387***	−0.000121***
	(0.000285)	(0.000371)	(0.000177)	(0.000527)	(0.000536)	(0.000383)	(0.000223)	(0.000463)	(0.00530)	(3.80×10^{-5})	(4.12×10^{-5})
$\ln(K/L)_{ft}$	0.00158**	0.00473***	−0.00315***	0.00927***	0.00793***	0.0151***	0.00831***	0.0353***	0.364***	−0.000115	0.000715***
	(0.000750)	(0.000954)	(0.000458)	(0.00137)	(0.00143)	(0.00121)	(0.000752)	(0.00328)	(0.0208)	(0.000131)	(0.000140)
$\ln(Software/L)_{ft}$	−0.00512**	−0.00714***	0.00201	−0.00184	−0.000907	0.0230***	0.00543***	0.0164*	−0.480***	−0.00481***	0.00588***
	(0.00206)	(0.00264)	(0.00128)	(0.00385)	(0.00397)	(0.00342)	(0.00204)	(0.00894)	(0.0313)	(0.000381)	(0.000408)
TFP_{ft}	0.000555***	0.00135***	−0.000809***	0.00186***	0.00192***	0.00261***	0.00195***	−0.00973***	−0.0182***	−0.000407***	-3.47×10^{-5}
	(0.000193)	(0.000249)	(0.000124)	(0.000372)	(0.000383)	(0.000348)	(0.000244)	(0.000783)	(0.00600)	(4.26×10^{-5})	(4.04×10^{-5})
$\ln(Patent/L)_{ft}$	−0.124***	−0.119***	−0.00479	0.173***	0.139***	0.0305	0.156***	−0.133***	−0.392***	−0.0145***	−0.0216***
	(0.0242)	(0.0307)	(0.0138)	(0.0405)	(0.0423)	(0.0336)	(0.0192)	(0.0149)	(0.0924)	(0.00283)	(0.00312)
Auxiliary predictor: non-environmental	–	–	–	–	–	–	–	−0.0920***	0.0542	–	–
								(0.0135)	(0.0709)		
Auxiliary predictor: environmental	–	–	–	–	–	–	–	0.00962	−0.312***	–	–
								(0.0142)	(0.0835)		
Observations	3,307,996	3,307,996	3,307,996	3,783,565	3,307,996	11,043,888	11,043,888	11,029,145	11,029,145	11,043,888	11,043,888
Hansen J	7.186	20.71	28.04	39.15	18.80	23.58	40.13	–	–	15.99	55.35
Hansen p-value	0.0275	3.19×10^{-5}	8.15×10^{-7}	3.15×10^{-9}	8.27×10^{-5}	7.56×10^{-6}	1.93×10^{-9}	–	–	0.000338	< 0.000001
Cragg–Donald	479,228	479,228	479,228	531,087	479,228	1.530×10^{6}	1.530×10^{6}	–	–	1.530×10^{6}	1.530×10^{6}
Kleibergen–Paap	1,832	1,832	1,832	1,874	1,832	2,653	2,653	–	–	2,653	2,653
Firm, destination–product, destination–year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Generated	Generated	Yes	Yes

Notes: Each displayed outcome column reports its corresponding estimate and observed controls; auxiliary first-stage regressions are not displayed. Environmental and non-environmental TBT stocks are treated as jointly endogenous and instrumented with four category-specific leave-one-out measures. Columns (1)–(7) are two-step linear IV-GMM models, columns (8)–(9) are IV Poisson models, and columns (10)–(11) are two-step IV-GMM linear probability models for exit and entry, respectively. Variable units and estimator interpretation follow Table 2. The Hansen tests reject the four-instrument system in columns (1)–(7) and (10)–(11), so the category-specific TBT coefficients require particular caution. Control coefficients remain non-causal conditional associations. Standard errors are clustered by destination–product. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

4.3 The role of tariffs and firm characteristics

The controls in Tables 2 and 3 distinguish productive efficiency, scale, workforce composition, and other firm capabilities. Their patterns are broadly similar across the two benchmarks. Because only TBT exposure is instrumented, these estimates describe conditional associations rather than causal effects of firm characteristics. Employment, capital intensity, software intensity, and patent intensity enter in natural logarithms; TFP enters directly as the estimated productivity index, and the skilled-worker share is measured in percentage points. For logged outcomes, the coefficients on logged firm characteristics are elasticities. In the $\ln(1+y)$ equations, they refer to $1+y$, and in IV Poisson, they refer to the conditional mean of trade. Entry and exit coefficients instead describe probability changes per log point, or per percentage point of the skill share. The discussion below therefore distinguishes upgrading within active flows from trade and transitions in the expanded relationship panel.

Tariffs. Higher tariffs are associated with lower export value and physical volume in the full-panel linear specifications. The positive-flow value association is also negative in the total-stock benchmark, although significant only at 10%; the corresponding volume estimate is statistically insignificant. These patterns are consistent with the conventional trade-cost role of tariffs. The evidence on quality is weaker: quality and unit-value estimates are statistically insignificant in the total-stock model and weakly negative in the disaggregated model, while quality-adjusted prices are statistically insignificant in both. IV Poisson also associates tariffs with lower volume but higher value, so the value result is sensitive to functional form. Entry is negatively associated with tariffs only in the disaggregated specification; exit is statistically insignificant in both. Since tariffs enter as $\ln(1+\text{Tariff})$, with rates measured in percentage points, the coefficients are not elasticities with respect to the untransformed tariff rate.

Employment. Within-firm employment growth is associated with higher measured quality and larger active export flows, alongside lower unit values and quality-adjusted prices. The combination is consistent with production scale supporting both upgrading and price competitiveness. For economic scale, a 10% increase in employment is associated with approximately 1.8% higher export value among active flows in the total-stock benchmark. The positive associations also extend to the full-panel log-one-plus outcomes, although IV Poisson yields negative associations for both value and volume. Employment is therefore strongly related to sales within active relationships, but the zero-inclusive results do not support a uniform expansion in trade. Positive entry and exit associations suggest more frequent changes in export relationships in both directions rather than an unambiguous improvement in survival. This distinction helps explain why firm scale should be assessed separately from the stability of its export portfolio.

High-skilled employment share. A higher skilled-worker share is associated with higher unit values (significant only at 10%) and higher quality-adjusted prices, but its quality association is statistically insignificant. Thus, the observed price premium is not accompanied by a detectable increase in demand-revealed quality. Both value and volume are lower among active flows and

in the full-panel linear models, whereas IV Poisson associates the skilled share with higher value and a statistically insignificant volume response. Workforce composition consequently has a different empirical profile from employment scale: a more skilled workforce does not, by itself, imply larger export flows or additional measured quality. Negative entry and exit associations point to less frequent transitions in the observed relationship panel. These conditional patterns leave open a distinct role for skills in adapting to regulation, which is examined through the interactions below.

Physical capital per worker. Capital intensity exhibits a more consistent association with export performance. Higher capital per worker is associated with higher quality and unit values, lower quality-adjusted prices, and greater value and volume in both active flows and the zero-inclusive specifications. Entry is also positively associated with capital intensity, while exit is statistically insignificant. This combination is consistent with physical capital supporting production capacity and quality upgrading without a commensurate increase in the price net of quality. Whether capital also moderates the response to TBTs is a separate question, addressed by the interaction specifications rather than these control estimates.

Software capital per worker. Software intensity has a different profile from physical capital. It is associated with lower measured quality and unit values, while quality-adjusted prices and positive-flow value and volume are statistically insignificant. The full-panel linear models nevertheless show higher value and volume; IV Poisson also shows higher value, significant only at 10%, but lower physical volume. Together with lower exit and higher entry probabilities, these estimates are consistent with software being related to the organisation and renewal of export relationships more than to measured product upgrading. Digital systems could facilitate documentation, coordination, or market management, but those activities are not observed directly. The contrasting volume results also mean that the estimates cannot establish a general increase in the quantity exported.

Total factor productivity. Higher TFP is associated with higher export quality, unit values, and sales among active relationships, together with lower quality-adjusted prices. The pattern is consistent with productive efficiency allowing firms to offer higher-quality goods at a lower price net of quality. Full-panel log-one-plus value and volume are also positively associated with productivity, but both IV Poisson associations are negative. Productivity is therefore related to stronger performance within active flows without a uniform positive association across the zero-inclusive models. Its negative exit association is consistent with greater retention of existing relationships, whereas entry is statistically insignificant. The logged-outcome coefficients are semi-elasticities per unit of the estimated productivity index, and the linear IV-GMM entry and exit coefficients are probability changes per unit of this index.

The positive association of productivity with quality and unit values is consistent with the endogenous-quality literature, in which productive firms can choose better inputs and offer higher-quality output (Verhoogen 2008; Kugler and Verhoogen 2012). Higher unit values can therefore accompany productive efficiency when quality also differs. These conditional control

estimates do not establish a causal productivity effect or identify the expenditures associated with quality adjustment.

Patent stock per worker. Patent intensity is associated with larger active export flows but lower unit values and demand-revealed quality; quality-adjusted prices are statistically insignificant. This combination suggests that formal inventive activity and the quality attributes valued in a particular export market need not coincide. Firm-wide patents may concern production processes or products other than the exported good, making them an imperfect proxy for the product-specific knowledge and resources needed for regulatory adjustment. In the expanded panel, log-one-plus volume is positive, log-one-plus value is statistically insignificant, and both IV Poisson outcomes are negative. Negative entry and exit associations further suggest less frequent changes in relationships rather than broader market access. The auxiliary predictors in the IV Poisson columns serve the nonlinear estimation procedure and do not represent additional economic mechanisms.

4.4 Robustness checks

4.4.1 Comparison with one-stage estimates

Appendix Tables B.2 and B.3 compare one-stage TBT associations with the benchmark IV results. Probit transition coefficients are index slopes and cannot be compared numerically with IV-GMM probability changes; the PPML and IV Poisson specifications also differ.

For total TBT exposure, the one-stage estimates reproduce higher quality and unit values, lower quality-adjusted prices, and higher active export value. Quality and unit-value responses are smaller than in Table 2, and physical volume remains statistically insignificant. Entry is negative in the one-stage model and positive in the IV benchmark; exit is negative in the former and statistically insignificant in the latter. Both one-stage PPML trade estimates are statistically insignificant, whereas benchmark IV Poisson volume is negative and significant. Agreement is therefore strongest for upgrading within active flows.

Disaggregation is less consistent with Table 3. Both categories have positive one-stage quality associations, whereas only environmental quality is significant in the IV benchmark. Environmental quality-adjusted price becomes statistically insignificant, and non-environmental quality-adjusted price is negative rather than positive. Non-environmental active value is positive, reversing its IV sign, while environmental active value becomes statistically insignificant. Environmental zero-inclusive volume is negative in both approaches, but its PPML value is statistically insignificant. Transition signs also differ. Thus, the environmental distinction and participation results are more sensitive to estimation approach than the total-stock upgrading pattern.

4.4.2 Controlling for home regulations imposed on each product

Product–year fixed effects in Appendix Tables B.4 and B.5 absorb annual product shocks shared across destinations. These fixed effects absorb shared home requirements alongside other product

shocks and cannot identify home regulation separately. The total-stock upgrading pattern survives, although the quality elasticity falls to less than half its benchmark size. Active value remains positive, significant only at 10%, and active volume statistically insignificant; IV Poisson value remains statistically insignificant and volume negative. The positive benchmark entry association becomes statistically insignificant. Environmental active-flow quality, unit value, quality-adjusted price, and value become statistically insignificant, while non-environmental quality is positive and quality-adjusted price negative. Environmental IV Poisson value and volume remain negative, and neither category has a significant transition estimate. The total-stock findings therefore persist more clearly than their attribution to environmental objectives.

4.4.3 Extra-EU destinations

Restricting the sample to extra-EU destinations in Appendix Tables B.6 and B.7 is particularly informative because tariffs and measured destination TBT exposure are coded as zero for intra-EU observations. This coding represents the maintained single market convention rather than a claim that technical or environmental obligations are absent within the EU. The extra-EU estimates assess sensitivity to the inclusion of these zero-coded observations. This restriction therefore focuses the analysis on variation in the technical requirements faced by Austrian exporters outside the single market. The extra-EU estimates preserve the benchmark total-stock pattern of higher quality, higher unit values, lower quality-adjusted prices, and higher export value among active relationships; the corresponding physical-volume estimate remains statistically insignificant. Relative to Table 2, zero-inclusive IV Poisson export value becomes positive and statistically significant, while volume remains negative and significant. Entry becomes statistically insignificant, whereas exit is negative and significant. In the disaggregated specification, environmental TBTs retain their positive quality association, but their IV Poisson value association becomes positive and significant, reversing the negative benchmark result in Table 3. Non-environmental TBTs also become positively associated with active export value, reversing their negative benchmark association. Environmental entry and exit are both negative and significant, while non-environmental transition estimates are statistically insignificant. Taken together, the extra-EU results associate TBT exposure with both quality upgrading and higher export revenues, without indicating a general expansion in physical trade or participation. These patterns are consistent with upgrading and stronger sales among exporters serving regulated markets outside the EU. However, differences in destination and product composition prevent attributing the changes relative to the benchmark solely to regulatory integration or greater variation in TBT exposure.

4.4.4 Sample of environmental goods

For environmental goods in Appendix Tables B.8 and B.9, total-stock quality and unit value become statistically insignificant, while active value and volume are positive and quality-adjusted price negative. IV Poisson value remains statistically insignificant, volume negative, and entry becomes negative. Disaggregation reveals positive environmental quality and unit-value associations and a lower quality-adjusted price, alongside negative non-environmental quality

and unit-value associations. Environmental active value is positive but both zero-inclusive value estimates are negative; IV Poisson volume becomes statistically insignificant. Non-environmental IV Poisson value is positive and volume negative. Environmental entry and exit are negative, while non-environmental transitions are positive. The restriction therefore reveals distinct category responses rather than a uniform strengthening of the benchmark effects for goods classified as environmental.

4.5 Firm characteristics and the interaction evidence

Appendix Tables B.10–B.15 examine whether the response to total TBT exposure varies with firm characteristics. These one-stage interactions address moderation, whereas the benchmark controls describe the direct conditional associations of those characteristics with export outcomes. Employment, capital, software, and patents enter in logs; skills enter as a percentage-point share, and TFP enters directly as the estimated productivity index. For logged outcomes, an interaction changes the TBT elasticity with respect to $1 + N^{TBT}$; for PPML, it changes the slope of the log conditional mean. Probit interactions concern the latent index and cannot be interpreted directly as interaction effects on probabilities. The main TBT coefficient gives the estimated association with TBT exposure when the characteristic equals zero, which is not generally representative of the sample. The discussion therefore concentrates on the direction of moderation rather than claiming an absolute TBT effect for a typical firm.

Research on endogenous quality links producer capabilities to input and output quality (Kugler and Verhoogen 2012), while firm-level evidence shows that standards affect exporters differently according to their characteristics (Fontagné et al. 2015; Disdier, Gaigné, et al. 2023). This literature motivates comparing regulatory associations across observed firm attributes. The interactions nevertheless do not identify compliance-cost reductions or causal returns to investment: the characteristics may also reflect endogenous adjustment, differences in products, and exporter selection.

Employment alone provides limited evidence that scale facilitates regulatory adaptation (Table B.10). Its interactions with quality, unit values, quality-adjusted prices, and active export value and volume are statistically insignificant. By contrast, the PPML value and volume interactions are negative, while the exit-index interaction is positive and the entry-index interaction negative. Thus, the favourable direct associations between employment and active export performance in the benchmark do not extend to a consistently more favourable response to TBT exposure. Firm size and the specific capabilities required for compliance should consequently be distinguished.

The skilled-worker share is more clearly related to sales adjustment than to additional measured quality (Table B.11). Its interactions with active export value and volume are positive, while the quality interaction is statistically insignificant. The negative quality-adjusted-price interaction, together with a weakly negative unit-value interaction, is consistent with skills supporting price competitiveness as regulatory exposure rises. PPML value also has a positive interaction, but the volume interaction is statistically insignificant. Both transition-index interactions are positive, which does not establish a net gain in participation. Read alongside the benchmark controls,

these results suggest that human capital may matter for managing the response to regulation even when a higher share of skilled workers has no detectable direct association with quality. The moderation is measured per percentage-point change in the share.

Physical capital provides evidence of complementarity between productive capacity and upgrading among active exporters (Table B.12). Higher capital intensity is associated with stronger positive TBT responses in quality, unit values, export value, and physical volume as well as with a more negative quality-adjusted-price response. These directions are consistent with firms using production assets to meet technical requirements while containing the price net of quality. Both transition-index interactions are negative, but the PPML value and volume interactions are statistically insignificant. Capital therefore moderates the adjustment within active flows more clearly than it moderates zero-inclusive trade; the estimates do not establish that capital-intensive firms obtain a larger overall market-access gain.

Software intensity is associated with adjustment on different margins (Table B.13). Its quality, unit-value, and active-value interactions are negative, its quality-adjusted-price interaction positive, and its active-volume interaction statistically insignificant. In contrast, both PPML trade interactions are positive; the exit-index interaction is negative and the entry-index interaction positive. This combination is consistent with digital capability supporting the management of export relationships without strengthening measured quality upgrading among active flows. It complements the benchmark software pattern, although the data do not identify whether documentation, coordination, or another activity accounts for the association.

TFP exhibits a broader pattern of favourable moderation (Table B.14). Its interactions with quality, active export value and volume, and PPML value and volume are positive, while the quality-adjusted-price interaction is negative and the unit-value interaction statistically insignificant. Greater productive efficiency is thus associated with stronger upgrading and sales responses as TBT exposure increases. Both transition-index interactions are negative, so additional entry does not follow directly from the favourable sales pattern.

The interaction $\ln(1 + N^{TBT}) \times TFP$ measures how the regulatory slope changes per unit of the estimated productivity index. Its sign does not establish that the TBT effect is positive at every productivity level.

Patent intensity does not produce the same moderation as productivity or physical capital (Table B.15). Its interactions with quality and active export value and volume are negative, while quality-adjusted price has a positive interaction and unit value is statistically insignificant. The PPML volume interaction is also negative, the value interaction statistically insignificant, and both transition-index interactions positive. These results suggest that a broad measure of inventive activity is insufficient to capture the product-specific knowledge and organisational resources needed for regulatory adaptation. They do not imply that innovation itself undermines compliance or quality.

Taken together, the interactions document different patterns across observed firm characteristics. Productivity and physical capital are associated with stronger upgrading and sales responses within active flows, skills with sales and price adjustment, and software with a different balance between active flows and zero-inclusive trade. These are conditional patterns: the

one-stage models cannot separate the contribution of a capability from investment undertaken in anticipation of regulation or from unobserved changes in products. Nor do the total-stock interactions identify moderation specific to environmental objectives. The reported significance levels are pointwise across multiple characteristics and outcomes rather than adjusted for multiple comparisons; the interaction evidence should consequently be read as exploratory conditional heterogeneity. The main empirical implication is that neither size nor a single innovation measure adequately summarises the heterogeneity in firms' responses to destination regulation.

5 Concluding remarks

Technical regulations in destination markets determine both what exporters supply and which relationships remain commercially viable. This paper examines these relations by linking Austrian firm–product–destination transactions to regulatory notifications, firm accounts, workforce characteristics, and patents. It compares quality, prices, and sales among active export flows with participation and trade including zeros in the expanded relationship panel. This distinction allows us to assess whether favourable outcomes among observed exporters coincide with broader improvements in trade and market access.

The most consistent empirical finding is that greater total TBT exposure is associated with higher demand-revealed quality and unit values and lower quality-adjusted prices among active exporters. The quality association survives the addition of product–year fixed effects, although its magnitude declines. Active export value is also higher, but its positive association is not accompanied by a statistically significant physical-volume response. In the zero-inclusive IV Poisson model, value is statistically insignificant and volume negative. The positive benchmark entry association becomes statistically insignificant with product–year effects. Taken together, these results support an upgrading interpretation more clearly than a general expansion in export activity or market access.

The environmental distinction is informative but less stable. In the benchmark results, environmental TBTs are associated with higher quality and active export value, lower quality-adjusted prices, and lower zero-inclusive IV Poisson value and volume. Non-environmental TBTs have a statistically insignificant quality association, higher observed and quality-adjusted prices, and lower value and volume within active flows; their full-panel linear trade associations are positive. The environmental quality association becomes statistically insignificant with product–year effects, and its zero-inclusive value association changes sign outside the EU. Moreover, all reported linear category-specific benchmark equations reject their joint overidentifying restrictions. These contrasts should therefore be retained as suggestive evidence about the distribution of outcomes rather than as a causal comparison of environmental and non-environmental regulation.

The interaction evidence further suggests that adaptation depends on several firm attributes. Productivity and physical capital intensity are associated with stronger quality and sales responses among active exporters, while skills are more closely related to sales and price adjustment and software to the management of relationships. Patent intensity and employment scale do not consistently reproduce these patterns. The one-stage interactions document heterogeneous

associations, but they do not identify either causal returns to investment, training, or patenting or the particular compliance activities responsible for the observed differences.

The policy implications extend beyond viewing technical regulation solely as an impediment to exports. The positive associations of total TBT exposure with demand-revealed quality and export value among active relationships are compatible with regulations making product attributes more credible to buyers and encouraging quality adjustment, as discussed in the standards-and-quality literature (Ghodsi and Stehrer 2022; Disdier, Gaigné, et al. 2023). The selected capital and productivity interaction patterns also suggest that firms' capacity to adapt matters for their export response. Technical requirements can therefore play a constructive role in market transactions. However, the separate estimates for environmental and non-environmental TBTs, together with the zero-inclusive trade and participation results, show that these potential benefits do not translate uniformly into higher export sales, greater physical trade, or wider market access.

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A Estimation details and variable definitions

This appendix provides additional details on the instrumental-variable and nonlinear estimators in addition to defining the empirical variables and estimation notation.

A.1 Instrumental-variable and nonlinear estimation details

The Stata estimation code defines $Z^{c,g}_{hjt}$ as the log of one plus the simple leave-one-destination-out worldwide average of stock g for product h. It defines $Z^{p,g}_{hjt}$ analogously from other products in destination j. These instrument families exclude the own cell but can still respond to common product trends or cross-product destination shocks. For fixed destination and product universes of sizes $J > 1$ and $H > 1$, let $\bar{N}^g_{ht}$ and $\bar{N}^g_{jt}$ be the respective all-destination and all-product arithmetic means. The untransformed leave-one-out means satisfy

$$M^{c,g}_{hjt} = \frac{J\bar{N}^g_{ht} - N^g_{hjt}}{J-1}, \tag{A.1}$$

$$M^{p,g}_{hjt} = \frac{H\bar{N}^g_{jt} - N^g_{hjt}}{H-1}. \tag{A.2}$$

Thus, exclusion of the own observation from a simple average does not by itself create an independent regulatory shock. In the balanced fixed-universe case, after absorbing product–year effects in a levels specification, the residualised country mean is $-1/(J-1)$ times the residualised own stock; after absorbing destination–year effects, the product mean has the analogous relationship. The actual instruments use $\ln(1+M)$ and may have varying coverage, so these exact linear residual relationships need not carry over unchanged to the reported regressions. Nevertheless, their identifying variation must be checked after transformation and fixed-effect removal: nonlinear curvature or changing coverage should not be mistaken for evidence of an exogenous diffusion shock. The reported first-stage statistics and Hansen tests do not resolve this construction issue. Examining the residualised first stages, the aggregation universes and missing-data rules, and alternative instruments based on predetermined exposure or genuinely external adoption variation is necessary before assigning a causal interpretation to these IV associations.

The linear first stage for one regulatory category is

$$R^g_{hjt} = \pi^g_c Z^{c,g}_{hjt} + \pi^g_p Z^{p,g}_{hjt} + \mathbf{\Pi}'_g \mathbf{W}_{fhjt} + \zeta^g_{fhjt}, \tag{A.3}$$

where $\mathbf{W}$ includes the stated controls and firm, product–destination, and destination–year effects. For the two-category model, R^{Env} and R^{NonEnv} are each projected on the four corresponding category-specific instruments with the same included controls. The first-stage projections provide the 2SLS starting point for the two-step IV-GMM estimator used in the reported linear specifications. The subsequent GMM step updates the moment weighting matrix using first-step residuals and allows for destination–product clustering. This procedure applies to the continuous outcomes, including the supplementary $\ln(1 + \text{value})$ and $\ln(1 + \text{volume})$ equations, and to the entry and exit indicators. For the binary transition outcomes, IV-GMM estimates a linear

probability model; its coefficients are changes in the probability of a recorded transition per log-point of $1 + N$ within the specified panel, conditional on instrument validity. Both stages additionally absorb product–year effects in the corresponding robustness specifications.

The nonlinear code first estimates PPML with absorbed firm, product–destination, and destination–year effects on export value, and then it saves their predictions as additional regressors in `ivpoisson cfunction`. This is a generated-regressor approximation to the treatment of high-dimensional effects, which is not identical to directly absorbing those effects in the final IV Poisson model. The reported nonlinear standard errors do not reflect a full bootstrap of the fixed-effect generation and IV steps.

For Poisson outcomes the conditional-mean interpretation of a coefficient β on $R = \ln(1 + N)$ is, for a proportional increase s in $1 + N$,

$$\frac{\mathbb{E}[X \mid R + \ln(1 + s), \mathbf{W}]}{\mathbb{E}[X \mid R, \mathbf{W}]} - 1 = \exp[\beta \ln(1 + s)] - 1. \tag{A.4}$$

Interpreting this as a causal percentage change requires a credible exclusion restriction and a correctly specified nonlinear model. The descriptive fixed-effect, nonlinear, and linear IV estimates share a destination–product clustering level in the reported code. They do not have identical likelihoods or samples. In particular, the Hansen J tests and Kleibergen–Paap statistics printed with the linear models should not be carried over as diagnostics for `ivpoisson cfunction`. A cluster bootstrap that repeats generated fixed effects, first stages, and nonlinear estimation would improve uncertainty assessment.

A.2 Variable definitions

Table A.1: Definitions of empirical variables and estimation notation

Symbol	Definition	Level, construction, or use
Indices and regulatory categories		
f	Austrian manufacturing firm	A firm represented in the export data
h	HS six-digit product	Product dimension of customs and regulatory data
j	Destination country	Foreign market
t	Calendar year	2013-2021 in the export panel
$g \in \{TBT, Env, NonEnv\}$	Regulatory category	Overall, environmental, or non-environmental TBTs
$\mathcal{G}$	Endogenous exposures in an IV specification	Either $\{TBT\}$ or $\{Env, NonEnv\}$
Trade outcomes and quality measurement		
X_{fhjt}	Export value	Positive customs value in active years and zero in inactive years of the expanded panel
q_{fhjt}	Physical export quantity	Customs quantity for active flows; set to zero in inactive relationship-years
p_{fhjt}	F.o.b. unit value	Export value divided by physical quantity for usable positive flows
r_{fhjt}	Positive export value	Export value conditional on an active relationship; equals $p_{fhjt}q_{fhjt}$ where quantity is available
$\widehat{\mathcal{Z}}_{fhjt}$	Estimated demand-revealed quality	$\ln \widehat{\mathcal{Z}}_{fhjt} = \widehat{\nu}_{fhjt}/(\sigma_h - 1)$
$\widetilde{p}_{fhjt}$	Quality-adjusted unit value	$p_{fhjt}/\widehat{\mathcal{Z}}_{fhjt}$; defined for the quality-estimation sample
σ_h	Elasticity of substitution across varieties	Product-specific values from Broda et al. (2017); $\sigma_h > 1$
ν_{fhjt}	Quality-recovery regression residual	Residual from regressing $\ln q + \sigma_h \ln p$ on product and destination–year effects in Equation (1)
ι_h, ι_{jt}	Quality-recovery fixed effects	Product and destination–year effects, respectively
I_{fhjt}	Export-status indicator	One when $X_{fhjt} > 0$, zero otherwise
$Entry_{fhjt}$	Entry indicator	$I_{fhjt}(1 - I_{fhj,t-1})$ where lagged status is observed
$Exit_{fhjt}$	Exit indicator	$(1 - I_{fhjt})I_{fhj,t-1}$ where lagged status is observed

Continued on next page

Table A.1 continued

Symbol	Definition	Level, construction, or use
y_{fhjt}	Generic regression outcome	Quality, price, trade, or participation outcome as specified in the relevant equation
Y_{fhjt}	Non-negative trade outcome	Export value or physical volume in the Poisson specifications
Observed regulatory variables and sample indicators		
N^{g}_{hjt}	Destination notification stock in category g	TBT notifications in force for product h, destination j, and year t
$N^{g,H}_{ht}$	Home notification stock in category g	Reported descriptively in Table B.1; not a treatment in the reported regressions
R^{g}_{hjt}	Transformed destination stock	$\ln(1 + N^{g}_{hjt})$; preserves cells with no notification
$Tariff_{hjt}$	Applied bilateral ad valorem tariff	Entered as $\ln(1 + Tariff_{hjt})$
$EnvGood_{h}$	Environmental-good indicator	Defines the environmental-products robustness sample
Observed firm characteristics and included controls		
Emp_{ft}	Number of employees	Firm size; entered in logarithms
TFP_{ft}	Total factor productivity	Productivity index ω recovered using Ackerberg et al. (2015), with inverse-hyperbolic-sine-transformed output and inputs; entered without further transformation
$(K/L)_{ft}$	Physical capital per employee	Capital intensity; entered in logarithms
$Low_{ft}, Medium_{ft}, High_{ft}$	Employment by education group	ISCED 1–2, 3–4, and 5–8, respectively
$Skill_{ft}$	Percentage of workers with tertiary education	$100 \times High/(Low + Medium + High)$
$(Software/L)_{ft}$	Software capital per employee	Entered in logarithms
$(Patent/L)_{ft}$	Patent stock per employee	Entered in logarithms
$\mathbf{X}_{ft}$	Vector of firm characteristics	Employment, TFP, capital, skills, software, and patents in the stated transformations
C_{ft}	Firm characteristic in an interaction	One element of $\mathbf{X}_{ft}$, examined separately
$\mathbf{X}^{(-C)}_{ft}$	Remaining firm controls	Excludes the characteristic included separately in the interaction
$\mathbf{C}_{fhjt}$	Included controls in the IV equations	Firm characteristics and the transformed bilateral tariff

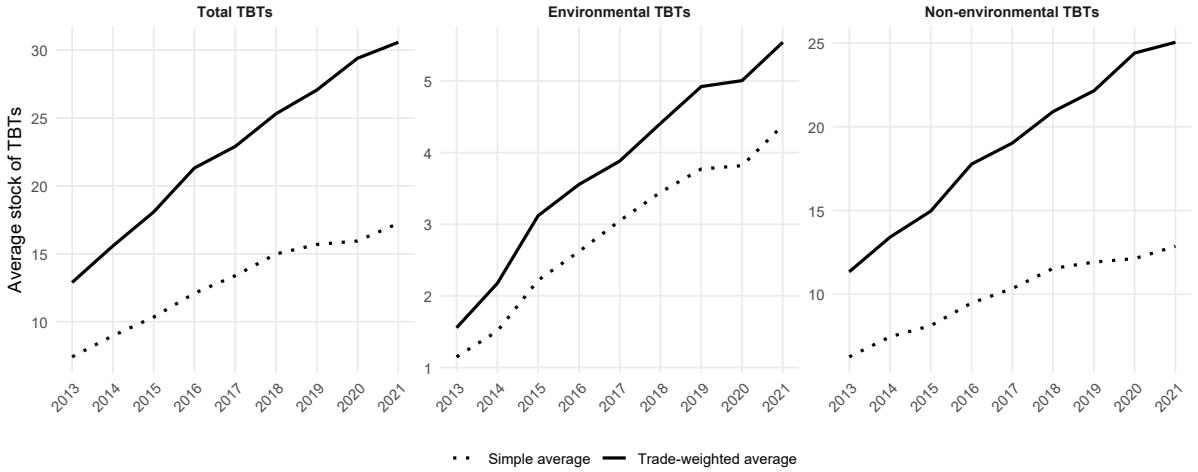
Continued on next page

Table A.1 continued

Symbol	Definition	Level, construction, or use
Instruments and estimation notation		
$M_{hjt}^{c,g}, M_{hjt}^{p,g}$	Untransformed leave-one-out means	Same product across other destinations, and other products within the same destination, respectively
$Z_{hjt}^{c,g}, Z_{hjt}^{p,g}$	Excluded regulatory instruments	$\ln(1 + M_{hjt}^{c,g})$ and $\ln(1 + M_{hjt}^{p,g})$
$\mathbf{Z}_{hjt}$	Vector of excluded instruments	Two total-stock instruments or four category-specific instruments
J, H	Sizes of the aggregation universes	Destination and product counts in the fixed-universe leave-one-out identities
$\bar{N}_{ht}^{g}, \bar{N}_{jt}^{g}$	All-destination and all-product means	Include the own cell in the respective aggregation universe
$\widehat{R}_{fhjt}^{g}$	Fitted regulatory exposure	Linear first-stage prediction in Equation (8)
$\mathbf{W}_{fhjt}$	Included controls and fixed effects	Compact notation used in Appendix A.1
$\widehat{\mathbf{F}}_{fhjt}$	Estimated fixed-effect components	Firm, product–destination, and destination–year predictions from preliminary PPML
$v_{fhjt}^{g}, \widehat{v}_{fhjt}^{g}$	Regulatory first-stage residual and estimate	Estimated residuals enter the Poisson control function
ζ_{fhjt}^{g}	Linear first-stage disturbance	Compact notation in Equation (A.3)
μ_{fhjt}^{Y}	Conditional mean of a trade outcome	Exponential mean in Equation (15)
ρ_{g}^{Y}	Control-function coefficient	Coefficient on the generated residual for exposure g
η_{fhjt}^{m}	Interaction-specification predictor	Conditional mean for OLS, log mean for PPML, or latent Probit index
$\alpha_f, \alpha_{hj}, \alpha_{jt}$	Benchmark fixed effects	Firm, product–destination, and destination–year, respectively
α_{ht}	Additional product–year fixed effect	Absorbs common annual product shocks in robustness specifications
ε_{fhjt}	Outcome-equation disturbance	Standard errors are clustered by destination–product

B Additional results

Figure B.1: Destination-country TBT stocks over time: full sample



Notes: The figure reports annual simple and export-value-weighted averages of the cumulative stocks of total, environmental, and non-environmental TBTs imposed by destination countries. The calculations are based on the full sample, including zero export flows. Export-value-weighted averages are calculated using firm-level export values as weights.

Table B.1: Descriptive statistics of continuous TBT stock variables

Sample	Variable	Mean	Std. Dev.	Min	Max
Panel A. Intensive-margin sample					
Destination	TBT_{hjt}	16.820	36.876	0	620
	$EnvTBT_{hjt}$	3.863	17.105	0	312
	$NonEnvTBT_{hjt}$	12.957	25.504	0	308
Home	TBT^{H}_{ht}	22.593	43.222	0	599
	$EnvTBT^{H}_{ht}$	6.062	21.402	0	311
	$NonEnvTBT^{H}_{ht}$	16.531	28.196	0	288
Panel B. Full sample					
Destination	TBT_{hjt}	13.591	32.165	0	620
	$EnvTBT_{hjt}$	3.103	14.859	0	312
	$NonEnvTBT_{hjt}$	10.488	22.065	0	308
Home	TBT^{H}_{ht}	20.950	40.808	0	599
	$EnvTBT^{H}_{ht}$	5.889	20.584	0	311
	$NonEnvTBT^{H}_{ht}$	15.061	25.696	0	288

Notes: The table reports descriptive statistics for cumulative destination-country and home-country stocks of total, environmental, and non-environmental TBTs. Destination stocks vary by product–destination–year, while home stocks vary by product–year. Panel A reports the intensive-margin sample, while Panel B reports the full sample including zero export flows.

Table B.2: Associations (one-stage estimates): overall destination TBT stock

	OLS: positive trade flows					Probit		PPML: including zeros	
	Q-adjusted price (1)	Quality (2)	Unit value (3)	Export value (4)	Export volume (5)	Exit (6)	Entry (7)	Export value (8)	Export volume (9)
$\ln(1 + TBT_{hjt})$	-0.00948^{***}	0.0296^{***}	0.0201^{***}	0.0284^{***}	0.00835	-0.00872^{***}	-0.00602^{***}	-0.0284	0.0480
	(0.00287)	(0.00604)	(0.00460)	(0.00861)	(0.00862)	(0.000446)	(0.000437)	(0.0304)	(0.0614)
$\ln(1 + \text{Tariff}_{hjt})$	0.00373	-0.0107^{*}	-0.00700	-0.0112	-0.00421	0.0109^{***}	0.00986^{***}	0.00169	-0.0131
	(0.00259)	(0.00573)	(0.00445)	(0.00778)	(0.00784)	(0.000509)	(0.000560)	(0.0173)	(0.0196)
Log employment	-0.0574^{***}	0.0282^{***}	-0.0292^{***}	0.172^{***}	0.201^{***}	0.0181^{***}	0.00735^{***}	0.842^{***}	0.783^{***}
	(0.00321)	(0.00652)	(0.00506)	(0.00964)	(0.00995)	(0.000360)	(0.000341)	(0.0383)	(0.0731)
High-skilled share (pp)	0.000576^{***}	-5.55×10^{-5}	0.000521^{*}	-0.00173^{***}	-0.00225^{***}	0.00136^{***}	0.00216^{***}	-0.00436	0.00343
	(0.000177)	(0.000372)	(0.000286)	(0.000531)	(0.000536)	(4.45×10^{-5})	(4.09×10^{-5})	(0.00396)	(0.00386)
Log physical capital per worker	-0.00313^{***}	0.00466^{***}	0.00152^{**}	0.00940^{***}	0.00788^{***}	-0.0135^{***}	0.000317	0.0235^{***}	-0.0112
	(0.000458)	(0.000954)	(0.000751)	(0.00137)	(0.00143)	(0.000376)	(0.000368)	(0.00827)	(0.0112)
Log software capital per worker	0.00213^{*}	-0.00743^{***}	-0.00530^{**}	-0.00639^{*}	-0.00109	-0.0293^{***}	0.0259^{***}	0.0345^{***}	0.0242
	(0.00128)	(0.00264)	(0.00206)	(0.00384)	(0.00397)	(0.00115)	(0.00103)	(0.0120)	(0.0195)
TFP	-0.000804^{***}	0.00134^{***}	0.000535^{***}	0.00241^{***}	0.00188^{***}	-0.00554^{***}	0.00214^{***}	0.00438^{***}	0.00862^{***}
	(0.000124)	(0.000249)	(0.000193)	(0.000371)	(0.000383)	(0.000155)	(0.000156)	(0.00123)	(0.00178)
Log patent stock per worker	-0.00650	-0.114^{***}	-0.121^{***}	0.0195	0.140^{***}	0.00837^{***}	0.0108^{***}	1.164^{***}	1.909^{***}
	(0.0138)	(0.0307)	(0.0242)	(0.0413)	(0.0423)	(0.00168)	(0.00161)	(0.240)	(0.190)
Generated firm effect	—	—	—	—	—	-0.0308^{***}	-0.0346^{***}	—	—
						(0.000359)	(0.000324)		
Generated product–destination effect	—	—	—	—	—	-0.0127^{***}	-0.00811^{***}	—	—
						(0.000241)	(0.000230)		
Generated destination–year effect	—	—	—	—	—	0.0452^{***}	0.130^{***}	—	—
						(0.00231)	(0.00244)		
Constant	3.701^{***}	-0.192^{***}	3.510^{***}	6.726^{***}	3.216^{***}	-1.353^{***}	-1.276^{***}	9.132^{***}	9.960^{***}
	(0.0193)	(0.0395)	(0.0306)	(0.0580)	(0.0595)	(0.00318)	(0.00291)	(0.246)	(0.480)
Observations	3,307,996	3,307,996	3,307,996	3,307,996	3,307,996	11,029,145	11,029,145	10,974,725	10,869,006
R^2	0.557	0.537	0.657	0.433	0.530	—	—	—	—
Pseudo-R^2	—	—	—	—	—	0.00202	0.00187	0.708	0.848
Absorbed firm FE	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Absorbed product–destination FE	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Absorbed destination–year FE	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes

Notes: Columns (1)–(5) use OLS for logged outcomes in the positive-flow sample. Columns (6)–(7) report one-stage Probit index coefficients, not marginal probability effects. The generated firm, product–destination, and destination–year effects enter Probit as covariates; these fixed effects are not absorbed in Probit. Columns (8)–(9) use PPML for value and volume in levels, including zeros. Tariffs enter as $\ln(1 + \text{Tariff})$; tariffs and the high-skilled share are expressed in percentage points. Standard errors in parentheses are clustered by product–destination. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.3: Associations (one-stage estimates): environmental and non-environmental TBT stocks

	OLS: positive trade flows					Probit		PPML: including zeros	
	Q-adjusted price (1)	Quality (2)	Unit value (3)	Export value (4)	Export volume (5)	Exit (6)	Entry (7)	Export value (8)	Export volume (9)
$\ln(1 + EnvTBT_{hjt})$	−0.00363	0.0160**	0.0124**	0.0109	−0.00148	0.00395***	0.000784	−0.0360	−0.117**
	(0.00270)	(0.00630)	(0.00496)	(0.00810)	(0.00816)	(0.000867)	(0.000837)	(0.0380)	(0.0588)
$\ln(1 + NonEnvTBT_{hjt})$	−0.00699**	0.0188***	0.0119**	0.0210**	0.00911	−0.0114***	−0.00684***	−0.0107	0.0945
	(0.00354)	(0.00714)	(0.00510)	(0.0106)	(0.0101)	(0.000630)	(0.000610)	(0.0336)	(0.0700)
$\ln(1 + \text{Tariff}_{hjt})$	0.00390	−0.0116**	−0.00766*	−0.0117	−0.00403	0.0111***	0.00994***	0.00213	−0.0137
	(0.00257)	(0.00574)	(0.00448)	(0.00772)	(0.00781)	(0.000515)	(0.000565)	(0.0170)	(0.0193)
Log employment	−0.0573***	0.0280***	−0.0294***	0.172***	0.201***	0.0180***	0.00732***	0.845***	0.787***
	(0.00321)	(0.00652)	(0.00507)	(0.00964)	(0.00995)	(0.000360)	(0.000340)	(0.0380)	(0.0731)
High-skilled share (pp)	0.000577***	-6.11×10^{-5}	0.000516*	−0.00173***	−0.00225***	0.00136***	0.00216***	−0.00442	0.00374
	(0.000177)	(0.000372)	(0.000286)	(0.000531)	(0.000536)	(4.45×10^{-5})	(4.09×10^{-5})	(0.00393)	(0.00379)
Log physical capital per worker	−0.00314***	0.00466***	0.00153**	0.00941***	0.00788***	−0.0135***	0.000338	0.0234***	−0.00999
	(0.000458)	(0.000954)	(0.000751)	(0.00137)	(0.00143)	(0.000376)	(0.000368)	(0.00822)	(0.0111)
Log software capital per worker	0.00212*	−0.00739***	−0.00527**	−0.00637*	−0.00110	−0.0294***	0.0258***	0.0345***	0.0242
	(0.00128)	(0.00264)	(0.00206)	(0.00384)	(0.00397)	(0.00115)	(0.00103)	(0.0120)	(0.0195)
TFP	−0.000805***	0.00134***	0.000538***	0.00242***	0.00188***	−0.00553***	0.00215***	0.00434***	0.00841***
	(0.000124)	(0.000249)	(0.000193)	(0.000371)	(0.000383)	(0.000155)	(0.000156)	(0.00122)	(0.00178)
Log patent stock per worker	−0.00641	−0.115***	−0.121***	0.0192	0.141***	0.00803***	0.0107***	1.168***	1.917***
	(0.0138)	(0.0307)	(0.0242)	(0.0413)	(0.0423)	(0.00168)	(0.00161)	(0.238)	(0.190)
Generated firm effect	—	—	—	—	—	−0.0308***	−0.0346***	—	—
						(0.000360)	(0.000324)		
Generated product–destination effect	—	—	—	—	—	−0.0128***	−0.00815***	—	—
						(0.000241)	(0.000230)		
Generated destination–year effect	—	—	—	—	—	0.0450***	0.130***	—	—
						(0.00230)	(0.00244)		
Constant	3.698***	−0.179***	3.519***	6.735***	3.217***	−1.353***	−1.276***	9.108***	9.922***
	(0.0194)	(0.0396)	(0.0306)	(0.0581)	(0.0595)	(0.00316)	(0.00289)	(0.247)	(0.486)
Observations	3,307,996	3,307,996	3,307,996	3,307,996	3,307,996	11,029,145	11,029,145	10,974,725	10,869,006
R^2	0.557	0.537	0.657	0.433	0.530	—	—	—	—
Pseudo-R^2	—	—	—	—	—	0.00203	0.00187	0.708	0.848
Absorbed firm FE	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Absorbed product–destination FE	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Absorbed destination–year FE	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes

Notes: Columns (1)–(5) use OLS for logged outcomes in the positive-flow sample. Columns (6)–(7) report one-stage Probit index coefficients, not marginal probability effects. The generated firm, product–destination, and destination–year effects enter Probit as covariates; these fixed effects are not absorbed in Probit. Columns (8)–(9) use PPML for value and volume in levels, including zeros. Tariffs enter as $\ln(1 + \text{Tariff})$; tariffs and the high-skilled share are expressed in percentage points. Standard errors in parentheses are clustered by product–destination. Environmental and non-environmental stocks enter jointly. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.4: Instrumental-variable estimates with product–year fixed effects: overall TBT stock

Panel A. Linear IV-GMM estimates

	Unit value (1)	Quality (2)	Q-adjusted price (3)	Positive value (4)	Positive volume (5)	ln(1 + value) (6)	ln(1 + volume) (7)
$\ln(1 + TBT_{hjt})$	0.0162**	0.0237***	−0.00814**	0.0222*	0.0107	0.0324***	0.0222***
	(0.00651)	(0.00861)	(0.00388)	(0.0114)	(0.0117)	(0.00917)	(0.00573)
Observations	3,305,224	3,305,224	3,305,224	3,780,798	3,305,224	11,042,551	11,042,551
Hansen p-value	0.275	0.353	0.799	0.621	0.771	0.000455	0.000123
Kleibergen–Paap	1,665	1,665	1,665	1,804	1,665	2,821	2,821

Panel B. Export levels and participation estimates

	IV Poisson value (8)	IV Poisson volume (9)	IV-GMM exit (10)	IV-GMM entry (11)
$\ln(1 + TBT_{hjt})$	0.00481	−0.0561***	0.000566	0.000841
	(0.00403)	(0.0168)	(0.000773)	(0.00106)
Observations	10,968,302	10,968,302	11,042,551	11,042,551
Hansen p-value	–	–	0.00185	0.0145
Kleibergen–Paap	–	–	2,821	2,821

Notes: Linear outcomes and the exit and entry indicators are estimated by two-step IV-GMM (`gmm2s`); export levels use IV Poisson. These specifications add product–year fixed effects to firm, destination–product, and destination–year fixed effects. All other details follow Table 2. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.5: Instrumental-variable estimates with product–year fixed effects: environmental and non-environmental TBTs

Panel A. Linear IV-GMM estimates

	Unit value (1)	Quality (2)	Q-adjusted price (3)	Positive value (4)	Positive volume (5)	ln(1 + value) (6)	ln(1 + volume) (7)
$\ln(1 + NonEnvTBT_{hjt})$	0.0119*	0.0213**	−0.00992**	0.0248*	0.0214	0.0128	0.0183***
	(0.00713)	(0.00995)	(0.00459)	(0.0136)	(0.0133)	(0.0104)	(0.00654)
$\ln(1 + EnvTBT_{hjt})$	0.00652	0.00555	0.00140	−0.00187	−0.0125	0.0292***	0.00684
	(0.00733)	(0.00914)	(0.00384)	(0.0110)	(0.0118)	(0.00914)	(0.00589)
Observations	3,305,224	3,305,224	3,305,224	3,780,798	3,305,224	11,042,551	11,042,551
Hansen p-value	0.472	0.521	0.670	0.194	0.663	0.00267	0.000805
Kleibergen–Paap	1,847	1,847	1,847	1,963	1,847	2,864	2,864

Panel B. Export levels and participation estimates

	IV Poisson value (8)	IV Poisson volume (9)	IV-GMM exit (10)	IV-GMM entry (11)
$\ln(1 + NonEnvTBT_{hjt})$	0.0175***	−0.0237	4.77×10^{-5}	0.000136
	(0.00676)	(0.0179)	(0.000904)	(0.00113)
$\ln(1 + EnvTBT_{hjt})$	−0.0267***	−0.0625**	0.00124	0.000959
	(0.00880)	(0.0247)	(0.000812)	(0.00101)
Observations	10,968,302	10,968,302	11,042,551	11,042,551
Hansen p-value	–	–	0.000341	2.76×10^{-5}
Kleibergen–Paap	–	–	2,864	2,864

Notes: Linear outcomes and the exit and entry indicators are estimated by two-step IV-GMM (`gmm2s`); export levels use IV Poisson. The two stocks enter jointly. Product–year fixed effects are added to the benchmark fixed effects. Standard errors are clustered by destination–product. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.6: Instrumental-variable estimates for extra-EU destinations: overall TBT stock

Panel A. Linear IV-GMM estimates

	Unit value (1)	Quality (2)	Q-adjusted price (3)	Positive value (4)	Positive volume (5)	ln(1 + value) (6)	ln(1 + volume) (7)
$\ln(1 + TBT_{hjt})$	0.0430***	0.0614***	−0.0186**	0.0918***	0.0117	0.104***	0.0190
	(0.0144)	(0.0180)	(0.00819)	(0.0238)	(0.0256)	(0.0246)	(0.0148)
Observations	1,460,118	1,460,118	1,460,118	1,852,565	1,460,118	6,294,854	6,294,854
Hansen p-value	0.115	0.365	0.441	0.459	0.101	0.0125	0.135
Kleibergen–Paap	1,325	1,325	1,325	1,499	1,325	2,489	2,489

Panel B. Export levels and participation estimates

	IV Poisson value (8)	IV Poisson volume (9)	IV-GMM exit (10)	IV-GMM entry (11)
$\ln(1 + TBT_{hjt})$	0.0597***	−0.115***	−0.00584***	0.000177
	(0.00469)	(0.0262)	(0.00192)	(0.00210)
Observations	6,278,170	6,278,170	6,294,854	6,294,854
Hansen p-value	–	–	0.00675	0.000113
Kleibergen–Paap	–	–	2,489	2,489

Notes: Linear outcomes and the exit and entry indicators are estimated by two-step IV-GMM (`gmm2s`); export levels use IV Poisson. The sample excludes EU destinations. All models contain the benchmark controls. Linear IV specifications absorb firm, destination–product, and destination–year fixed effects; the nonlinear specifications include generated effect predictors. Standard errors are clustered by destination–product. See Table 2 for estimator definitions. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.7: Instrumental-variable estimates for extra-EU destinations: environmental and non-environmental TBTs

Panel A. Linear IV-GMM estimates

	Unit value (1)	Quality (2)	Q-adjusted price (3)	Positive value (4)	Positive volume (5)	ln(1 + value) (6)	ln(1 + volume) (7)
$\ln(1 + NonEnvTBT_{hjt})$	0.0272	0.0376*	−0.0117	0.0647**	0.00764	0.148***	0.0639***
	(0.0166)	(0.0212)	(0.00959)	(0.0275)	(0.0293)	(0.0284)	(0.0174)
$\ln(1 + EnvTBT_{hjt})$	0.0324***	0.0540***	−0.0203***	0.0798***	0.0264	0.0380	−0.0231
	(0.0116)	(0.0148)	(0.00689)	(0.0204)	(0.0213)	(0.0244)	(0.0153)
Observations	1,460,118	1,460,118	1,460,118	1,852,565	1,460,118	6,294,854	6,294,854
Hansen p-value	0.223	0.430	0.000136	1.58×10^{-6}	1.68×10^{-5}	0.0129	0.0545
Kleibergen–Paap	768.4	768.4	768.4	847.7	768.4	1,356	1,356

Panel B. Export levels and participation estimates

	IV Poisson value (8)	IV Poisson volume (9)	IV-GMM exit (10)	IV-GMM entry (11)
$\ln(1 + NonEnvTBT_{hjt})$	0.0423***	−0.0163	−0.000414	0.00375
	(0.00637)	(0.0316)	(0.00210)	(0.00244)
$\ln(1 + EnvTBT_{hjt})$	0.0550***	−0.377***	−0.00852***	−0.00517***
	(0.0115)	(0.0479)	(0.00190)	(0.00188)
Observations	6,278,170	6,278,170	6,294,854	6,294,854
Hansen p-value	–	–	0.00384	< 0.000001
Kleibergen–Paap	–	–	1,356	1,356

Notes: Linear outcomes and the exit and entry indicators are estimated by two-step IV-GMM (`gmm2s`); export levels use IV Poisson. The two TBT stocks enter jointly and are instrumented by their four category-specific world and own measures. The sample excludes EU destinations. All other details follow Table 3. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.8: Instrumental-variable estimates for environmental goods: overall TBT stock

Panel A. Linear IV-GMM estimates

	Unit value (1)	Quality (2)	Q-adjusted price (3)	Positive value (4)	Positive volume (5)	ln(1 + value) (6)	ln(1 + volume) (7)
$\ln(1 + TBT_{hjt})$	−0.0290	−0.00753	−0.0201**	0.0462*	0.103***	0.0202	0.0114
	(0.0184)	(0.0214)	(0.00797)	(0.0247)	(0.0266)	(0.0580)	(0.0481)
Observations	985,844	985,844	985,844	1,111,238	985,844	3,168,590	3,168,590
Hansen p-value	0.0215	0.0487	0.870	0.637	0.132	0.00132	0.000472
Kleibergen–Paap	1,124	1,124	1,124	1,088	1,124	1,435	1,435

Panel B. Export levels and participation estimates

	IV Poisson value (8)	IV Poisson volume (9)	IV-GMM exit (10)	IV-GMM entry (11)
$\ln(1 + TBT_{hjt})$	0.00688	−0.243***	−0.00103	−0.00688***
	(0.00737)	(0.0257)	(0.00253)	(0.00257)
Observations	3,165,593	3,165,593	3,168,590	3,168,590
Hansen p-value	–	–	0.00141	0.0202
Kleibergen–Paap	–	–	1,435	1,435

Notes: Linear outcomes and the exit and entry indicators are estimated by two-step IV-GMM (`gmm2s`); export levels use IV Poisson. The sample is restricted to products classified as environmental goods. All other details follow Table 2. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.9: Instrumental-variable estimates for environmental goods: environmental and non-environmental TBTs

Panel A. Linear IV-GMM estimates

	Unit value (1)	Quality (2)	Q-adjusted price (3)	Positive value (4)	Positive volume (5)	ln(1 + value) (6)	ln(1 + volume) (7)
$\ln(1 + NonEnvTBT_{hjt})$	-0.0830^{***}	-0.0817^{***}	0.00188	0.0123	0.0891^{***}	0.245^{***}	0.175^{***}
	(0.0225)	(0.0256)	(0.00955)	(0.0294)	(0.0339)	(0.0550)	(0.0446)
$\ln(1 + EnvTBT_{hjt})$	0.0576^{***}	0.0831^{***}	-0.0227^{***}	0.0442^{*}	0.0281	-0.255^{***}	-0.187^{***}
	(0.0163)	(0.0183)	(0.00775)	(0.0254)	(0.0282)	(0.0475)	(0.0352)
Observations	985,844	985,844	985,844	1,111,238	985,844	3,168,590	3,168,590
Hansen p-value	0.00159	0.000286	0.00284	0.148	0.0387	0.00126	0.00295
Kleibergen–Paap	238.2	238.2	238.2	250.6	238.2	353.8	353.8

Panel B. Export levels and participation estimates

	IV Poisson value (8)	IV Poisson volume (9)	IV-GMM exit (10)	IV-GMM entry (11)
$\ln(1 + NonEnvTBT_{hjt})$	0.0507^{***}	-0.309^{***}	0.0152^{***}	0.00657^{**}
	(0.0132)	(0.0534)	(0.00317)	(0.00317)
$\ln(1 + EnvTBT_{hjt})$	-0.0728^{***}	0.0810	-0.0142^{***}	-0.0135^{***}
	(0.0171)	(0.0617)	(0.00258)	(0.00281)
Observations	3,165,593	3,165,593	3,168,590	3,168,590
Hansen p-value	–	–	1.13×10^{-8}	0.000178
Kleibergen–Paap	–	–	353.8	353.8

Notes: Linear outcomes and the exit and entry indicators are estimated by two-step IV-GMM (`gmm2s`); export levels use IV Poisson. The sample is restricted to environmental goods and the two stocks enter jointly. All models include benchmark controls. Linear IV specifications absorb fixed effects; nonlinear specifications include generated effect predictors. Standard errors are clustered by destination–product. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.10: One-stage TBT heterogeneity: firm employment

	Q-adjusted price (1)	Quality (2)	Unit value (3)	Positive value (4)	Positive volume (5)	Exit (6)	Entry (7)	PPML value (8)	PPML volume (9)
$\ln(1+TBT_{hjt})$	−0.00696	0.0203**	0.0134**	0.0209	0.00751	−0.0113***	0.00713***	0.0921	0.245**
	(0.00516)	(0.00914)	(0.00628)	(0.0155)	(0.0151)	(0.00145)	(0.00137)	(0.0626)	(0.115)
$\ln(Emp_{ft})$	−0.0565***	0.0251***	−0.0314***	0.170***	0.201***	0.0174***	0.0111***	0.887***	0.844***
	(0.00344)	(0.00677)	(0.00519)	(0.0103)	(0.0106)	(0.000483)	(0.000453)	(0.0430)	(0.0744)
$\ln(1+TBT_{hjt}) \times \ln(Emp_{ft})$	−0.000445	0.00163	0.00119	0.00133	−0.000149	0.000476**	−0.00243***	−0.0190**	−0.0320**
	(0.000782)	(0.00122)	(0.000735)	(0.00235)	(0.00224)	(0.000237)	(0.000222)	(0.00891)	(0.0158)
Observations	3,307,996	3,307,996	3,307,996	3,307,996	3,307,996	11,029,145	11,029,145	10,974,725	10,869,006

Notes: OLS is used for columns (1)–(5), Probit for (6)–(7), and PPML for (8)–(9). Models include benchmark controls; OLS and PPML absorb fixed effects, while Probit includes generated effect predictors. Standard errors are clustered by destination–product. The interaction is not instrumented. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.11: One-stage TBT heterogeneity: skilled-worker share

	Q-adjusted price (1)	Quality (2)	Unit value (3)	Positive value (4)	Positive volume (5)	Exit (6)	Entry (7)	PPML value (8)	PPML volume (9)
$\ln(1+TBT_{hjt})$	−0.00477	0.0273***	0.0225***	0.0143	−0.00822	−0.0100***	−0.00711***	−0.0645*	0.0253
	(0.00299)	(0.00620)	(0.00471)	(0.00896)	(0.00897)	(0.000601)	(0.000554)	(0.0336)	(0.0657)
$Skill_{ft}$	0.00140***	−0.000452	0.000951**	−0.00421***	−0.00516***	0.00117***	0.00199***	−0.0123**	−0.00171
	(0.000237)	(0.000497)	(0.000384)	(0.000712)	(0.000723)	(0.0000652)	(0.0000607)	(0.00496)	(0.00571)
$\ln(1+TBT_{hjt}) \times Skill_{ft}$	−0.000420***	0.000201	−0.000218*	0.00126***	0.00148***	0.000122***	0.000104***	0.00291**	0.00212
	(0.0000810)	(0.000174)	(0.000132)	(0.000243)	(0.000239)	(0.0000324)	(0.0000295)	(0.00126)	(0.00207)
Observations	3,307,996	3,307,996	3,307,996	3,307,996	3,307,996	11,029,145	11,029,145	10,974,757	10,869,006

Notes: The skilled-worker share is measured in percentage points. Estimator, controls, fixed effects, clustering, and interpretation follow Table B.10. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.12: One-stage TBT heterogeneity: capital intensity

	Q-adjusted price (1)	Quality (2)	Unit value (3)	Positive value (4)	Positive volume (5)	Exit (6)	Entry (7)	PPML value (8)	PPML volume (9)
$\ln(1+TBT_{hjt})$	−0.00266	0.0189***	0.0163***	0.00797	−0.00828	−0.00455***	−0.000889	−0.0566	0.0322
	(0.00296)	(0.00626)	(0.00479)	(0.00889)	(0.00893)	(0.000584)	(0.000575)	(0.0352)	(0.0593)
$\ln(K/L)_{ft}$	0.00396***	−0.00643***	−0.00247*	−0.0119***	−0.00941***	−0.00935***	0.00542***	−0.00320	−0.0209
	(0.000960)	(0.00184)	(0.00139)	(0.00288)	(0.00295)	(0.000540)	(0.000528)	(0.0212)	(0.0160)
$\ln(1+TBT_{hjt}) \times \ln(K/L)_{ft}$	−0.00389***	0.00608***	0.00219***	0.0117***	0.00948***	−0.00266***	−0.00324***	0.0128	0.00594
	(0.000459)	(0.000836)	(0.000614)	(0.00138)	(0.00140)	(0.000254)	(0.000248)	(0.00802)	(0.00590)
Observations	3,307,996	3,307,996	3,307,996	3,307,996	3,307,996	11,029,145	11,029,145	10,974,757	10,869,006

Notes: Estimator, controls, fixed effects, clustering, and interpretation follow Table B.10. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.13: One-stage TBT heterogeneity: software capital intensity

	Q-adjusted price (1)	Quality (2)	Unit value (3)	Positive value (4)	Positive volume (5)	Exit (6)	Entry (7)	PPML value (8)	PPML volume (9)
$\ln(1+TBT_{hjt})$	-0.0104^{***}	0.0350^{***}	0.0245^{***}	0.0313^{***}	0.00674	-0.00786^{***}	-0.00777^{***}	-0.0571^{*}	0.0264
	(0.00289)	(0.00605)	(0.00462)	(0.00867)	(0.00868)	(0.000490)	(0.000494)	(0.0313)	(0.0624)
$\ln(Software/L)_{ft}$	−0.00342	0.0243^{***}	0.0208^{***}	0.0103	−0.0106	-0.0244^{***}	0.0162^{***}	-0.192^{***}	-0.0691^{*}
	(0.00276)	(0.00470)	(0.00346)	(0.00829)	(0.00856)	(0.00166)	(0.00150)	(0.0596)	(0.0359)
$\ln(1+TBT_{hjt}) \times \ln(Software/L)_{ft}$	0.00304^{**}	-0.0173^{***}	-0.0143^{***}	-0.00911^{**}	0.00519	-0.00321^{***}	0.00624^{***}	0.102^{***}	0.0587^{***}
	(0.00134)	(0.00211)	(0.00148)	(0.00401)	(0.00410)	(0.000817)	(0.000729)	(0.0251)	(0.0163)
Observations	3,307,996	3,307,996	3,307,996	3,307,996	3,307,996	11,029,145	11,029,145	10,974,725	10,869,006

Notes: Estimator, controls, fixed effects, clustering, and interpretation follow Table B.10. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.14: One-stage TBT heterogeneity: total factor productivity

	Q-adjusted price (1)	Quality (2)	Unit value (3)	Positive value (4)	Positive volume (5)	Exit (6)	Entry (7)	PPML value (8)	PPML volume (9)
$\ln(1+TBT_{hjt})$	−0.00802***	0.0283***	0.0203***	0.0240***	0.00372	−0.00647***	−0.00447***	−0.0389	0.0380
	(0.00287)	(0.00604)	(0.00460)	(0.00860)	(0.00860)	(0.000487)	(0.000488)	(0.0307)	(0.0619)
TFP_{ft}	0.00148***	−0.000580	0.000901***	−0.00444***	−0.00534***	−0.00380***	0.00331***	−0.00256	0.00473**
	(0.000211)	(0.000403)	(0.000307)	(0.000632)	(0.000650)	(0.000230)	(0.000234)	(0.00194)	(0.00191)
$\ln(1+TBT_{hjt}) \times TFP_{ft}$	−0.00139***	0.00116***	−0.000222	0.00416***	0.00438***	−0.00115***	−0.000762***	0.00550***	0.00537***
	(0.000104)	(0.000195)	(0.000145)	(0.000313)	(0.000318)	(0.000112)	(0.000113)	(0.00120)	(0.00131)
Observations	3,307,996	3,307,996	3,307,996	3,307,996	3,307,996	11,029,145	11,029,145	10,974,725	10,869,006

Notes: Estimator, controls, fixed effects, clustering, and interpretation follow Table B.10. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table B.15: One-stage TBT heterogeneity: patent intensity

	Q-adjusted price (1)	Quality (2)	Unit value (3)	Positive value (4)	Positive volume (5)	Exit (6)	Entry (7)	PPML value (8)	PPML volume (9)
$\ln(1+TBT_{hjt})$	-0.0122^{***}	0.0332^{***}	0.0210^{***}	0.0365^{***}	0.0155^{*}	-0.0101^{***}	-0.00738^{***}	-0.0198	0.0675
	(0.00291)	(0.00606)	(0.00460)	(0.00872)	(0.00871)	(0.000490)	(0.000491)	(0.0315)	(0.0627)
$\ln(Patent/L)_{ft}$	-0.0425^{***}	-0.0661^{**}	-0.109^{***}	0.128^{***}	0.236^{***}	-0.00738^{***}	-0.00457^{*}	1.325^{***}	2.287^{***}
	(0.0150)	(0.0331)	(0.0259)	(0.0450)	(0.0459)	(0.00247)	(0.00237)	(0.222)	(0.246)
$\ln(1+TBT_{hjt}) \times \ln(Patent/L)_{ft}$	0.0167^{***}	-0.0223^{***}	-0.00562	-0.0500^{***}	-0.0444^{***}	0.0102^{***}	0.00992^{***}	-0.0462	-0.0992^{**}
	(0.00307)	(0.00566)	(0.00413)	(0.00920)	(0.00923)	(0.00129)	(0.00123)	(0.0360)	(0.0460)
Observations	3,307,996	3,307,996	3,307,996	3,307,996	3,307,996	11,029,145	11,029,145	10,974,725	10,869,006

Notes: Estimator, controls, fixed effects, clustering, and interpretation follow Table B.10. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

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