Structural Estimation of the Effects of Technical Non-Tariff Measures*

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Abstract

Regulatory activity in non-tariff measures is at the forefront of the trade policy debate. We estimate the trade and macroeconomics effects of regulatory developments over 2002–2017 combining structural gravity estimates and general equilibrium projections. The trade cost effects of regulatory changes vary on the bilateral level and across sectors. A decrease in bilateral regulatory differences is the main driver for increasing trade flows and real income particularly for countries in East Asia & Pacific, Europe & Central Asia, and South Asia.
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1 Introduction

Non-tariff measures (NTMs) and associated frictions to international trade are currently a major policy issue (see e.g. Lamy, 2013). These measures do not only include policies that primarily regulate trade, but also policies with non-trade and/or non-economic objectives.[1] Such measures are frequently referred to as standard-like technical measures and are the most prevalent type of NTMs. They often follow policy objectives reflecting citizens' preferences, such as health and quality concerns, and typically apply to domestic and foreign firms. However, the heterogeneity in their design across countries and sectors creates differences in regulatory profiles vis-a-vis trade partners in terms of the number, stringency and structure of the measures imposed, which causes trade costs that vary on the country-pair level. This study focuses on such trade cost related aspects of technical measures and the potential (unintended) economic effects of regulatory changes in an economy characterized by global supply chains with intermediate and sectoral linkages.

More specifically, we analyze the effects of changes in trade costs induced by changes in technical regulation taking place from 2012 – 2017 on global trade patterns and economic welfare.[2] We first estimate sector- and pair-specific trade elasticities and ad-valorem equivalent trade costs (AVEs) related to NTM changes conditioned on a structural gravity equation that incorporates two measures of regulatory changes, namely the regulatory stringency and pairwise regulatory difference. Regulatory stringency is the average number of technical measures per product in a given sector, varies by sector and importer and is common across exporters, while pairwise regulatory difference measures bilateral regulatory differences as the difference between harmonization and divergence events and varies by sector and country pair. The fact that technical measures mostly apply in a non-discriminatory fashion across all import sources makes it necessary to address their effects in a general equilibrium framework to correctly estimate their total effects. Therefore, we assess the effects of estimated trade cost changes within a general equilibrium model that nests our structural gravity equation and includes interna-

[1] We follow the definition established by multiple international institutions and define NTMs as measures "...that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both" (UNCTAD, 2017, p. 3). This wide definition of measures translates into a classification of NTMs that includes policies not thought of as traditional trade policy instruments but with spillover effects on trade (see UNCTAD, 2019).

[2] We focus on real GDP and income changes induced by changes in trade costs, but acknowledge that welfare aspects related to technical measures' non-economic objectives are an important raison d'être for these measures (for specific applications see e.g. Disdier and Marette (2010) and Otsuki et al. (2001)).

tional sectoral input-output linkages. The model is aggregated to 77 regions and 20 goods sectors, such that the gains from accounting for sectoral disaggregation and input-output linkages can be realized. Furthermore, we investigate how changes in trade costs, trade flows and real income differ when accounting for bilateral NTM information (measured by bilateral regulatory differences) and depend on the specification of the NTM-related trade cost in the general equilibrium model – that is, whether it is modeled as a price margin or as an iceberg cost.

Our approach to estimating the effects of trade policies relies on a structural gravity model and is in line with structurally-estimated general equilibrium trade models. The structural gravity estimation framework imposes structural restrictions (e.g. in the form of multilateral resistances) to the estimation of trade costs effects (J. E. Anderson, 1979; J. E. Anderson and van Wincoop, 2003) and is consistent with several theoretical models (Arkolakis et al., 2012; Head and Mayer, 2014). To identify the mechanisms underlying the real income effects, the structural form of the demand and supply sides of the general equilibrium model must be specified. In this regard, sectoral disaggregation (e.g. Caliendo and Parro, 2015; Ossa, 2015) and intermediate linkages (Caliendo and Parro, 2015) play a notable role.

Our study contributes to two lines of research. First, it relates to the econometric literature that identifies NTM effects on trade.[3] The trade cost specification in our structural gravity equation extends those in Vogt (2022) and Xiong and Beghin (2014) by allowing for heterogeneous NTM coefficients in the form of interactions of the NTM variables with predicted trade shares (see Chen and Novy, 2021).[4] Unlike aggregate import demand equations used to estimate NTM effects on trade (e.g. Beghin et al., 2015; Kee and Nicita, 2022; Kee et al., 2009), the gravity framework also allows us to introduce pairwise varying trade costs to account for regulatory harmonization and divergence between partners. These bilateral differences in regulatory profiles are important to isolate the trade-restricting component of standard-like NTMs from the trade-promoting component that technical measures may entail. The distinction between the trade-promoting and the trade-restricting components of NTMs contrasts with prior research that only includes NTMs with a priori trade-restrictive properties as part of the identification

[3]Many studies estimate the trade effects of different NTMs using a gravity model (e.g. Bratt, 2017; Ghodsi, 2019; Ghodsi and Stehrer, 2022; Kinzius et al., 2019) and using country-level import equations (e.g. Niu et al., 2018). Cadot and Gourdon (2016) analyze the effect of NTMs on prices.

[4]Chen and Novy, 2021 use predicted trade shares to address the simultaneity bias associated with trade share interactions. By contrast, Kee and Nicita (e.g. 2022) interact NTMs with world trade shares.

strategy, [5] which excludes from the analysis a significant number of NTMs that are often the result of citizens' preferences and relevant market access requirements for firms. Moreover, the exclusion of a set of technical measures may underestimate the effects of policy changes, as long as the excluded NTMs are related to the ones included in the analysis – e.g. if the implementation of policy changes takes place through different types of technical measures and a subset of them is excluded from the analysis. Finally, we use an interaction with the international border (see Heid et al., 2021) to identify the international trade effect of the non-discriminatory component of technical measures, captured by a stringency index, and adjust it by adding a margin common to international and domestic trade (see Freeman et al., 2021; Vogt, 2022).[6]

Our research also adds to the estimation of the effects of NTM-related policies in multi-country, multi-sectoral general equilibrium models. Several studies identify the effects of NTM-related policies on trade and economic welfare indirectly by disentangling a non-tariff component of PTAs and tariff effects. Fontagné et al. (2022) conclude that the inclusion of a PTA dummy does not significantly affect the distribution of tariff elasticities and captures the NTM effects of PTAs (e.g. mutual recognition of standards and certification procedures). This indirect approach underlies the estimates of the potential effects of the Transatlantic Trade and Investment Partnership (TTIP) agreement in Egger et al. (2015) and the the economic effects of the Brexit in Felbermayr et al. (2022). Alternatively, other studies directly estimate the costs of NTM policies (see CEPR, 2013 and Dhingra et al., 2017 for analyses of the TTIP and the Brexit, respectively). The estimated trade and welfare effects are sensitive to the modeling approach. TTIP's expected welfare effects vary widely from 0.2% to 10.1% depending on the study design (Bekkers and Rojas-Romagosa, 2019), while the effects of decreasing harmonization resulting from Brexit, modeled as an increase in non-tariff trade costs between the UK and the EU, imply welfare losses for the UK of 1.3% (Dhingra et al., 2017) and consumption losses ranging from 0.76% and 2.1% (Felbermayr et al., 2022).[7] However, these studies do

[5]E.g. Fontagné et al. (2015) use WTO Specific Trade Concerns to assess their heterogeneous effect on different margins of firm-level trade, or Kee and Nicita (2022) estimate the effect of trade restrictive border measures on fraudulent customs declarations. This relates to studies suggesting that specific NTMs substitute for reductions in tariffs implemented over the past decades (S. P. Anderson and Schmitt, 2003; Beverelli et al., 2019; Niu et al., 2020).

[6]Other studies use an international border interaction to identify the international trade effect of e.g. services trade policies (Reverdy, 2023), institutions (Beverelli et al., 2023), or trade facilitation (Oberhofer et al., 2021). This identification strategy is not feasible for product-level analyses because of limited data availability of domestic flows.

[7]The magnitude of the welfare effects of trade policy cost changes is comparable to the effects of other trade cost reductions. Bekkers et al. (2018b) simulate the economic impact of reduced transportation costs via the Northern

not address the effect of technical measures because technical measures are typically imposed independent of PTAs, such that the non-tariff content of PTAs does not capture them. Webb et al. (2020) and Walmsley and Strutt (2021) specifically investigate the effects of changes in technical measures on welfare for six ASEAN countries and find that a 20%reduction in baseline trade costs generate welfare gains mostly ranging from USD 300 million to USD 3 billion depending on modeling assumptions and whether trade costs are reduced within ASEAN or vis-a-vis all trade partners.

Our research contributes to the general equilibrium analysis of technical measures in three ways. First, we consider the effects of all policy changes vis-á-vis all partners, which is quantitatively relevant, because of the non-discriminatory character of most technical measures. This is, to the best of our knowledge, the first study to conduct a global evaluation of the economic impact of changes in technical measures. Second, the effects are conditioned on pair-specific trade elasticities of regulatory changes in technical measures estimated econometrically. Finally, we show how the different specifications of the trade policy changes in the general equilibrium model affect the results.

We find that changes in technical regulation over 2012–2017 increase net global trade and real income by 0.49% and 0.13%, respectively. These positive economic effects are relatively small compared with gains reported by other studies as a result of trade facilitation measures (see Oberhofer et al., 2021) or deep PTAs (e.g. Egger et al., 2015). However, our results uncover substantial regional and country differences. Particularly, upper middle income countries in East Asia & Pacific increase trade flows and further integrate into the global economy, whereas North America and Latin America & the Caribbean experience an overall decrease in imports and exports, mainly because of increasing trade costs on the American continent. Furthermore, the estimated income effects are very heterogeneous on the country level. For individual countries, regulatory changes can have sizeable effects, comparable to leaving or concluding a deep PTA. Policymakers should monitor changes of technical regulation, notably of main partners, because trade cost associated with such regulatory developments can substantially

Passage and find welfare gains of up to 0.5% for some European and East-Asian countries. Moreover, the improvements in trade facilitation infrastructure between 2006 – 2012 increase the welfare of middle- and low-income countries by 0.98% (Oberhofer et al., 2021). An upper bound estimate of welfare gains associated with reducing international trade costs is provided by J. E. Anderson et al. (2018), who report welfare gains from removing all international border costs for manufacturing trade ranging from 5% to 40%, which are significantly higher than those implied by studies analyzing explicitly trade policy changes. Finally, sizable welfare gains are expected from services liberalization. Benchmarking services trade policies to the least restrictive country, Reverdy (2023) estimates that such partial liberalizations increase average real income by 4.8%.

affect the international competitiveness of domestic firms.

Our findings show that the non-discriminating nature of technical measures implies that changes in technical regulation are best modeled with a wide geographic scope, because introducing or withdrawing a technical measure implies trade cost changes vis-a-vis all import and export partners, whereas isolated scenarios with a narrow geographic scope neglect important third-country effects. We also demonstrate that trade and income effects are a function of the trade cost specification. Econometric estimates conditioned on a single NTM indicator, which captures a mix of effects related to bilateral regulatory differences and importer's regulatory stringency, tend to underestimate the trade costs associated with regulatory divergence and the potential trade-promoting effects of regulatory stringency. The magnitude of the income effects is sensitive to whether NTM-related trade costs are defined as a trade tax or an iceberg trade cost, which calls for a data-based method to represent NTM costs.

The next section presents the structural gravity equation, parameterization of the trade cost function, identification strategy for the effect of bilateral regulatory difference and regulatory stringency, as well as the control function approach to address endogeneity of PTAs and regulatory differences. We further detail how elasticities obtained from the gravity estimation and regulatory changes in the NTM database are transformed into AVE trade cost changes. The section ends with a description of the general equilibrium model and corresponding introduction of NTM-related trade cost changes to the model. Section 3 presents elasticities from the gravity estimation, changes in technical regulation, as well as corresponding trade cost changes from 2012 to 2017 that enter the general equilibrium assessment. Subsequently, we highlight changes in trade patterns between country groups differentiated by income-level and region, as well as how sectoral regulatory changes contribute to global changes in trade. We further elaborate on macroeconomic effects and demonstrate their sensitivity with respect to different modeling assumptions. Finally, Section 4 concludes.

2 Methodology

We analyze global trade and macroeconomic effects of changes in bilateral regulatory differences and changes in regulatory stringency of technical regulations – represented by N^i with $i \in \{\text{dif}, \text{str}\}$ – that take place between 2012 and 2017. The analysis is conducted in three steps.

First, we introduce an NTM trade cost formulation into a standard gravity framework that disentangles NTM-related trade effects caused by bilateral regulatory differences and those that are common to all import sources (Xiong and Beghin, 2014). The latter effect is further adjusted by an effect common to domestic and international trade that is retrieved in a second stage fixed effect decomposition (Freeman et al., 2021; Vogt, 2022). Second, based on the estimated NTM and substitution elasticities we construct AVE trade costs corresponding to changes (introduction and/or withdrawal) in NTMs taking place between 2012 and 2017. Third, we simulate the effect of these trade cost changes on trade and macroeconomic outcomes using the general equilibrium model of Corong et al. (2017).

2.1 Empirical gravity equation

Equations (1) and (2) describe the empirical gravity model estimated for each sector $k \subseteq [1,\ldots,K]$ in two stages using Pseudo Poisson Maximum Likelihood (PPML, Santos Silva and Tenreyro, 2006). Equation (1) shows the first stage, where we estimate the effect of N^i on international trade under the inclusion of origin and destination fixed effects, while Equation (2) retrieves a NTM-effect common to international and domestic trade in the second stage (Vogt, 2022).

$$X_{od} = \exp\left[Z_{od}\beta - \sigma t_{od} + \sum_i B * N^i\left(\beta_1 + \beta_2 m_{od} + \beta_3 e_{od} + \beta_4 PTA^T\right) + \mu_o + \eta_d + \varepsilon_{od}\right] \qquad (1)$$

$$\text{with} \quad i \in \{\text{dif}, \text{str}\}$$

$$\widetilde{X}_{od} = \exp\left[Z_d\alpha + \alpha \mathrm{N}_d^{\text{str}} + \alpha \widehat{P}_d^{1-\sigma} + \alpha E_d + \varepsilon_{od}\right] \qquad (2)$$

$$\text{with} \quad \widetilde{X}_{od} = X_{od} * \exp\left(-Z^*_{od}\hat{\beta}\right) * \exp\left(-\hat{\mu}_o\right) \quad \text{and} \quad \widehat{P}_d^{1-\sigma} = \frac{E_d}{\exp\left(\hat{\eta}_d\right)} E_0^{-1}$$

Here, in the first stage Eq. (1) dependent variable X_{od} represents trade flows from origin o to destination d that include internal, as well as zero trade flows. We control for bilateral trade costs Z_{od} and applied tariffs t_{od}, which enter (1) as $\ln(1 + t_{od}/100)$. Moreover, we interact NTM variables N^i with an international border dummy B, the share of country o in d's imports (m_{od}), share of country d in o's exports (e_{od}), and a dummy indicating the presence of legally binding SPS or TBT PTA provisions (PTA^T). Origin and destination fixed effects μ_o and η_d

control for origin- and destination-specific determinants of trade, including inward and outward multilateral resistance (J. E. Anderson and van Wincoop, 2003). In Equation (2), we constrain origin fixed effect μ_o and variables in Z^*_{od} (composed of Z_{od}, N^i and its interaction terms, and t_{od}) to their first stage estimates ($\hat{\mu}_o$, $\hat{\beta}$, $\hat{\sigma}$) and regress a transformed dependent variable ($\widetilde{X}_{odk}$) on destination-specific controls Z_d, expenditure E_d and the empirical version of inward multilateral resistance ($\widehat{P}^{1-\sigma}_{dk}$) as defined by Fally (2015).

The main variables of interest are two NTM trade cost dimensions N^i reflecting regulatory differences and stringency. Bilateral regulatory differences are expressed as the difference between harmonization and divergence events ($N^{\text{dif}}_{od} = N^{\text{har}}_{od} - N^{\text{div}}_{od}$), with N^{har}_{od} defined as the number of common measure types imposed by origin o and destination d, and N^{div}_{od} defined as the number of measure types only applied by destination d but not by origin o. N^{dif}_{od} decreases in divergence and increases in harmonization events, and consequently we expect the coefficient to be positive. Regulatory stringency (N^{str}_d) is the average number of measures per product in a given sector and varies by destination country d. It includes all technical measures – i.e. those levied on foreign and domestic firms, as well as those imposed on foreign firms only.[8]

We allow for heterogeneity of the NTM effect with respect to trade shares of the importer and exporter and technical PTA provisions.[9] The pair-specific parameters associated with N^i $i = \{str, dif\}$ have the following specification:

$$\beta^i_{od} = \beta^i_1 + \beta^i_2 \hat{m}_{od} + \beta^i_3 \hat{e}_{od} + \beta^i_4 PTA^{T,pre}_{od} + \beta^i_5 PTA^{T,pos}_{od} \tag{3}$$

Equation (3) characterizes (asymmetric) pair-specific effects of the NTM indicators through a constant baseline effect (β_1) and several interactions—namely, interactions of the NTM indicators with the share of the source o on imports in destination d (import share, $\hat{m}_{od}$), the share of a destination d in exports of o (export share, $\hat{e}_{od}$), and with the indicator variables $PTA^{T,pre_{od}}$ and $PTA^{T,pos}_{od}$ for PTAs between the pair od that contain legally enforceable technical provisions and enter into force before and after 2012 (the first year in the period of analysis),

[8] For more detail see Appendix A.

[9] Kee et al. (2009) allow for varying trade effects depending on comparative advantage in import demand equations, and several studies allow for varying elasticities of trade costs in the gravity framework depending on variables capturing comparative advantage and GDP (Bratt, 2017), based on different locations on the demand curve characterized by the level of trade between two countries (Chen and Novy, 2021), and resulting from market power (Kee and Nicita, 2022) of the importer or exporter.

respectively. The interactions with import and export shares capture different considerations which imply that compliance costs of technical measures vary at the pair level. Both import and export shares reflect proximity of trade partners in terms of natural determinants of trade integration. Also, the import share in country d is a proxy for competitiveness of source o in destination d, while the export share in source o is related to market power of a destination d in source country o.[10] The expected effects of import and export shares are a priori ambiguous.

Import and export shares affect the trade effect of technical measures by capturing the degree of market integration, exporter competitiveness, potential motivation to implement trade protective measures, as well as market power. On the one hand, the magnitude of the NTM elasticity may decrease with increasing import and export shares. This is the case if large trade shares primarily reflect a high degree of market integration and corresponding closer regulatory preferences between trade partners. Thus, changes in technical measures imply relatively lower changes in compliance costs and trade promoting effects, i.e. lower effects on trade. Regarding trade promoting effects, this assumes that informational asymmetries are lower between natural trading partners, which neutralizes one of the main underlying causes for NTMs' trade promoting effects. Moreover, the effect of trade shares on NTM elasticities similarly decreases if larger trade shares reflect larger market power of the importer such that compliance costs are not passed through to consumers in the destination country, provided the exporter's supply is sensitive. Conversely, if smaller trade shares reflect less market power, the full effect of NTMs passes through to the importers without attenuation. On the other hand, larger import shares may also exacerbate NTM effects. This may be the case if large import shares induce the imposition of technical measures that are particularly trade restrictive and cause exporters with large market shares to divert trade to other destinations; an effect enabled by larger market power of the importer (see also Kee and Nicita, 2022).[11] Furthermore, trade-promoting effects of technical measures may be amplified if relatively competitive exporters with large trade shares are able to better leverage them.[12]

[10]Note that importer and exporter shares have a different meaning in (Kee and Nicita, 2022), because they use importer and exporter shares in world trade to measure market power. Chen and Novy (2021) derive interactions with import and export shares in a gravity equation based on a translog preferences function.

[11]Kee and Nicita (2022) also note that exporters may not be able to divert exports if the importer has a very large import share relative to the world. In this case, we may expect that the parameter associated with predicted import shares is close to zero at the upper tail of the world import share distribution. We consider this extreme case as empirically rare and do not model nonlinearities in the interactions.

[12]See e.g. Herghelegiu (2018) for the effect of transnational business groups attendance at the WTO Ministerial Conferences on the presence of NTMs.

To address potential simultaneity bias in the interaction terms we follow Chen and Novy (2021) and construct predicted trade shares. For this we regress X_{od} on the exogenous trade cost determinants distance, differences in latitude, common language, common colonizer, common border and international border dummy, as well as on origin and destination fixed effects.[13] The predicted exogenous part of X_{od} is used to construct the share of origin o in d's imports $\hat{m}_{od} = \hat{X}_{od}/\sum_o \hat{X}_{od}$ and the share of destination d in o's exports $\hat{e}_{od} = \hat{X}_{od}/\sum_d \hat{X}_{od}$, which we interact with N^i.

Finally, we include two interactions with dummies capturing the presence of legally enforceable technical provisions in PTAs entering into force pre-2012 and post-2012. PTAs active before 2012 are expected to attenuate the effect of technical measures to the extent that they represent high integration between partners before NTM changes, especially if PTAs include provisions relative to harmonization and mutual recognition. PTAs signed after 2012 may also attenuate the trade-restricting effects of NTMs if they enter into force before the technical measure. Yet, PTAs signed after 2012 may amplify the trade-promoting effects of existing technical measures by including technical provisions that reduce further informational asymmetries between partners (e.g. harmonization and mutual recognition).

The identification of N^i's effect on international trade depends on whether the associated trade costs are relevant for foreign firms only or are applicable to domestic firms, too. N^{dif}_{od}-related trade costs capture that complying with similar types of measures on the home market as imposed on the export market potentially reduces trade costs for exporting firms. Thus, the types of technical measures included in N^{dif}_{od} apply to foreign and domestic firms, whereas the underlying trade cost concept is only relevant for international trade. As a consequence, Equation (1) completely identifies N^{dif}_{od}-related trade costs.

By contrast, regulatory stringency N^{str}_{d} is destination-specific and includes measures domestic producers are most likely required to comply to, as well – e.g. labeling, conformity assessments, restricted use of substances. After controlling for the trade costs effects of N^{dif}_{od}, N^{str}_{d} represents the net effect of trade-promoting (e.g. through reduction in asymmetric information) and trade-restricting (e.g. through compliance cost increases) effects associated with regulatory stringency.

In Equation (1) we measure the effect of regulatory stringency on international relative to

[13] Chen and Novy (2021) show the validity of their procedure in simulated experiments.

domestic trade by interacting N_d^{str} with the international border dummy (B). The border interaction resolves collinearity with destination fixed effect η_d (Heid et al., 2021). As noted by Freeman et al. (2021) this effect needs to be adjusted by a trade effect that is common to international and domestic trade for policies that are equally imposed on domestic producers, which is absorbed by η_d in Equation (1). Thus, we follow Vogt (2022) and estimate second stage Equation (2) that decomposes fixed effect η_d into the effect of N_d^{str} common to domestic and international trade, as well as two destination-specific terms consistent with the Armington-based gravity equation, i.e. inward multilateral resistance ($P_d^{1-\sigma}$) and expenditure (E_d). Vector Z_d controls for institutional quality, governance, and polity, which affect international and domestic trade (Beverelli et al., 2023; Francois and Manchin, 2013) and likely correlate with regulatory stringency. The discriminatory effect of regulatory stringency on international trade ($\beta_{od}^{*,\text{str}}$) is retrieved by adding its respective coefficients over Equation (1) and (2), i.e. $\beta_{od}^{*,\text{str}} = \beta_{od}^{\text{str}} + \alpha^{\text{str}}$.

Endogeneity issues

Regulatory differences and stringency are a function of trading relationships between countries and consequently are likely to be subject to simultaneity bias. With respect to bilateral regulatory differences we address the resulting endogeneity with a standard control function approach (Cameron and Trivedi, 2013).[14] For this we include residual ϕ_{od} from an OLS regression for N_{od}^{dif} in Equation (1).

$$N_{od}^{\text{dif}} = Z_{od}^{\#}\beta + I_{od}\beta^{I} + \pi_o + \lambda_d + \phi_{od} \tag{4}$$

Similarly, to control the endogeneity of PTAs we follow Egger et al. (2011) and augment (1) with the inverse Mills ratio based on a Probit regression for a general PTA dummy and PTA^T, i.e. $PTA \in \{PTA^D, PTA^T\}$:

$$PTA = Z_{od}^{\#}\beta + I_{od}\beta^{I} + \delta_o + \kappa_d + \zeta_{od} \tag{5}$$

Equations (4) and (5) include vector $Z_{od}^{\#}$, which is composed of all variables of Z_{od} except

[14] Endogeneity of the effect of regulatory stringency on international relative to domestic trade is controlled for by the destination fixed effect(Beverelli et al., 2023; Heid et al., 2021).

the general PTA and border dummy, as well as origin (π_o, δ_o) and destination (λ_d, κ_d) fixed effects.[15]

In addition, we instrument with standard trade cost variables (I_{od}) because regulatory differences and PTA membership are a function of shared history, common culture, and existing trading relationships. Correspondingly, our pool of candidate instruments represents common legal and colonial history, common religion, whether two countries used to be the same country, geographic proximity, as well as cultural similarities.[16] For the final selection of j instruments – and by extension the composition of Z_{od} in (1) – we follow Egger et al. (2011) and test their joint significance (relevance) in Equations (4) and (5), i.e. we test whether we can reject $H_0 : \beta_j = 0, \forall j$ in favor of $H_1 : \beta_j \neq 0$ for at least one j. Furthermore, we estimate Equation (1) including I_{od} and test whether $H_0 : \beta_j = 0, \forall j$ cannot be rejected in favor of $H_1 : \beta_j \neq 0$, i.e. whether any of the instruments significantly determines trade (exclusion restriction). In both cases, tests of joint significance are conducted based on bootstrapped standard errors.

2.2 Scenario construction

We estimate the effect of regulatory changes from 2012 to 2017 based on real changes in NTMs captured by the underlying database. The five year period under investigation is compatible with the NTM data, which for most countries was collected for 2016 and later. Furthermore, the Global Trade Analysis Project (GTAP) database used in the gravity estimations and simulation exercise is for 2017 and consequently undistorted with respect to shifts in trade patterns due to the 2020 COVID pandemic and trade policy developments after the 2016 US election. The role of NTMs imposed counter-cyclical to economic downturn is minimized by choosing 2012 as an end year, which is sufficiently long after the 2008/2009 financial crisis.

More specifically, we define N^i_Δ as the change in regulatory stringency (str) and differences (dif) from base year 2017 to 2012, i.e. $\left(N^i_{12} - N^i_{17}\right)$. Thus, the trade costs associated with N^i_Δ represent the change in trade costs necessary to estimate the contribution of regulatory

[15] Equations (4) and (5) exclude domestic observations because corresponding regulatory differences are by design zero and countries cannot form a PTA with themselves. The control function for these observation is set to zero, i.e. it enters Equation 1 as mean-neutral.

[16] See e.g. Egger et al. (2015, 2011) and Helpman et al. (2008), who use the same (or similar) variables to instrument for the selection into PTAs and/or trade. With respect to NTMs, Kee and Nicita (2022) justify using neighboring countries' technical measures as instrumental variables based on cultural and historical ties, as well as similar trade patterns. In contrast to their approach, we directly use indicators for cultural similarities and historical relationships as instruments, which allows us to control for multilateral resistance and other destination- and origin-specific determinants of trade by including fixed effects μ_o and η_d.

developments since 2012 to trade and income in 2017. A value of $N_{\Delta}^{\text{dif}} < 0$ for a given exporter-importer pair od means that exporters face fewer types of measures imposed on the import market but not on their home market in 2017 compared to 2012, and vice versa for $N_{\Delta}^{\text{dif}} > 0$. Analogously, $N_{\Delta}^{\text{str}} < 0$ translates into an increase in the average number of measures per product in a given sector imposed by destination country d in 2017 compared to 2012, and vice versa for $N_{\Delta}^{\text{str}} > 0$.

Furthermore, we assess the relevance of including bilateral regulatory differences as a determinant of trade and income changes by estimating Equation (1) with and without N_{od}^{dif}. The specification that includes N_{od}^{dif} is referred to as the heterogeneous NTM effect (HET) model, whereas the specification with N_{d}^{str} only is referred to as the single indicator (SI) model.

In summary, the different N_{Δ}^{i} are combined to four scenarios:

1. **Dif – HET** with $i \in \{\text{dif}\}$: Assesses the contribution of trade cost changes caused by bilateral regulatory harmonization and divergence to trade and income in 2017.

2. **Str – HET** with $i \in \{\text{str}\}$: Assesses the contribution of trade cost changes caused by changes in regulatory stringency imposed in an MFN fashion to trade and income in 2017. We control for bilateral regulatory differences in Equations (1) and (2) when estimating the trade cost effect of regulatory stringency.

3. **Str – SI** with $i \in \{\text{str}\}$: Assesses the contribution of trade cost changes caused by changes in regulatory stringency imposed in an MFN fashion to trade and income in 2017. We exclude bilateral regulatory differences from Equation (1) when estimating the trade cost effect of regulatory stringency. Thus, we evaluate the importance of different NTM trade cost specifications (HET vs. SI) with respect to trade and income outcomes by comparing Str – SI to All – HET and Str – HET.

4. **All – HET** with $i \in \{\text{dif, str}\}$: Assesses the contribution of trade cost changes caused by bilateral regulatory harmonization and divergence and changes in regulatory stringency imposed in an MFN fashion to trade and income in 2017.

We follow Bekkers et al. (2018a) and calculate the AVE trade cost changes $\tilde{t}_{od}^{s}$ of N_{Δ}^{i} for each scenario s via:

$$(1-\hat{\sigma})\ln(1+\tilde{t}^s_{od}) = \sum_i \hat{\beta}^i_{od} N^{\mathrm{i}}_{\Delta} \Leftrightarrow \tilde{t}^s_{od} = \exp\left\{\frac{\sum_i \hat{\beta}^i_{od} N^{\mathrm{i}}_{\Delta}}{(1-\hat{\sigma})}\right\} - 1 \tag{6}$$

Here, $\hat{\beta}^i_{od} \in \left\{\hat{\beta}^{\mathrm{dif}}_{od}, \hat{\beta}^{(*),\mathrm{str}}_{od}\right\}$ constitutes the NTM effect including interactions with the predicted importer ($\hat{m}_{od}$) and exporter ($\hat{e}_{od}$) trade shares, as well as a technical PTA provision dummy, and $\hat{\sigma}$ represents the trade elasticity estimated directly from applied tariffs. We convert $\tilde{t}^s_{od}$ with the hyperbolic tangent function to cut off values beyond 100% and -100% (Cadot and Gourdon, 2016).[17]

Trade costs changes $\tilde{t}^s_{od}$ depend on two components: the total NTM effect $\hat{\beta}^i_{od}$ (see Equation (3)) and its elements, as well as the change in NTM variables. We ensure the robustness of both components in the following way.

First, we evaluate the significance of $\hat{\beta}^i_{od}$ at different levels of predicted importer and exporter shares and calculate $\tilde{t}^s_{od}$ only for observations with $\hat{\beta}^i_{od}$ significant at the 10% level. For this, we divide importer and exporter shares into ten bins and evaluate $\hat{\beta}^i_{od}$ at bin-midpoints for all bin combinations – i.e. 100 combinations in total for each N^i. Each of those $\hat{\beta}^i_{od}$ is simultaneously bootstrapped with Equations (1) and (2) enabling us to calculate t-statistics and p-values. Moreover, the PTA-effect is only included if interactions of PTA^T with N^i are jointly significant in (1).[18] We create separate dummy variables for the general PTA effect and PTA^T differentiated by whether PTAs entered into force after 2012 or not. This allows us to test whether newly concluded PTAs have already developed an effect on trade. If we find significant trade effects of post-2012 technical provisions we account for phase-in effects by constructing a $\tilde{t}^s_{od}$ that is an average of $\tilde{t}^s_{od}$ with $PTA^T = 1$ and $PTA^T = 0$ weighted by the number of years the PTAs has been in force since 2012.

In addition, we assume that the total effect of our regulatory difference indicator is positive ($\beta^{\mathrm{dif}}_{od} > 0$) and set significant cases with $\beta^{\mathrm{dif}}_{od} < 0$ to zero. With respect to regulatory stringency N^{str}_d, we assume that the coefficient represents the net effect of trade-promoting properties of quality-related measures and the trade cost increasing impact of more stringent regulation and border NTMs. Thus, a trade-promoting effect of N^{str}_d indicates dominating demand side

[17] The hyperbolic tangent function applied to $\tilde{t}^s_{od}$ is defined as $\left[\exp\left(2\tilde{t}^s_{od}\right)-1\right]/\left[\exp\left(2\tilde{t}^s_{od}\right)+1\right]$. The function condenses values approximately between $[80, 100]$ and $[-100, -80]$ but leaves values ranging from $[-80, 80]$ relatively unchanged. The final set of $\tilde{t}^s_{od}$ includes two observations with $\tilde{t}^s_{od} = 100$.

[18] If the interaction term is included and the total NTM effect is insignificant for $PTA^T = 1$, we use the total NTM effect for $PTA^T = 0$, if it is significant.

effects, while a trade decreasing effect of N_d^{str} suggests dominating trade cost effects.

Second, we examine changes in bilateral regulatory differences N_Δ^{dif} for values that suggest unrealistic changes in technical measures and potentially generate relatively large trade cost changes. For most countries regulatory data is only available for a specific cross-section with entry-into-force dates indicating the year from when a certain measure type is imposed. Thus, we know when measure types entered into force that are still imposed in the year of data collection, but lack information about the regulatory profile prior to that. For example, a labeling requirement that entered into force in 2016 and is imposed in the year of data collection (e.g. 2017) may be a new measure type (i.e no labeling requirement in force before 2016) or may be a replacement of a labeling policy in force before 2016. In the former (latter) case the regulatory structure of the policy imposing country changes (remains constant). Thus, we would model false changes in regulatory structure if the new measure is a replacement of an existing policy. In terms of the regulatory differences indicator this means that relatively high negative/positive values of N_Δ^{dif} imply a notable increase/decrease in the number of harmonized relative to divergent measures between 2012 and 2017. To identify cases of uncharacteristic regulatory change we compare N_Δ^i to an estimated regulatory change that is based on neighboring and reference countries' changes in technical measures, as well as SPS and TBT notifications to the WTO. These estimated $\hat{N}_\Delta^i$ replace outlier regulatory changes.[19]

2.3 General equilibrium model

We simulate the trade and income impacts of global regulatory changes between 2012 and 2017 using the general equilibrium model of Corong et al. (2017). The model is a global, comparative static general equilibrium model that captures international, sector-level input-output linkages. On the supply side, the model features a constant elasticity of substitution (CES) production structure, while its demand side is modeled as a constant differences of elasticities (CDE) private expenditure system. Consistent with our Armington-based gravity framework demand for trade is governed by a CES function with products from different countries being imperfect substitutes. Equation 1 estimates the corresponding substitution elasticity $\hat{\sigma}$, which applies to substitution between different international import sources and

[19] For regulatory stringency, we impute an indicator of regulatory change based on WTO notifications and changes of measure types. See Appendix C and H for more details on the NTM data, imputation and outlier detection.

substitution between domestic and international trade. It is also the elasticity used to transform the trade volume effect of changes in NTMs into AVE trade cost changes. Moreover, we assume that the trade balance is fixed, which reflects the short-term character of our experiment by limiting the investment response to changes in NTM-induced trade costs.

We model changes in NTMs not only as changes in iceberg trade costs, but also as changes in export and import taxes to account for rent seeking as a possible determinant of technical measures.[20] This way, we assess the sensitivity of real income effects with respect to whether and where NTM-related rents accrue.

In general, all three mechanisms cause a price distortion between the domestic price in the exporting country and the price paid by consumers in the importing country. This leads to deviations in trade patterns from an undistorted state (allocative inefficiencies) and affects prices received for exports and paid for imports (terms-of-trade). Trade taxes additionally affect regional income via tax revenues, which accrue to the regional household, while changes in iceberg trade costs imply additional changes in efficiency on the importer side.

More specifically, implementing trade cost changes via export taxes ($\tilde{t}^{s,\text{exp}}$) drives a wedge between the domestic price in the exporting country and the free-on-board (FOB) price. Changes in tax revenue due to regulatory changes between 2012 and 2017, i.e. in our case NTM-related rents, accrue to the household of the exporting country. By contrast, changing import taxes ($\tilde{t}^{s,\text{imp}}$) affects the difference between the cost, insurance, and freight (CIF) price and prices paid by consumers, with changes in NTM-related rents accruing to the household of the importing country. Analogous to import taxes, changes in iceberg trade cost ($\tilde{t}^{s,\tau}$) are levied on the CIF price.[21] A reduction/increase in iceberg trade costs further features an efficiency improvement/deterioration by changing the quantities of a good that need to be shipped to satisfy demand (Hertel et al., 2001). This expansion effect is akin to a technology shift for the importer whose production costs increase with NTM-related costs.[22]

To test the sensitivity of results to implementing trade cost changes as a trade tax versus ice-

[20]See e.g. Beverelli et al. (2019) and Niu et al. (2020) for a trade policy substitution argument or Herghelegiu (2018) for showing a positive relationship between lobbying activities at WTO Ministerial Conferences and presence of technical measures.

[21]Thus, modeling NTMs via import taxes and iceberg trade costs compared to export taxes leads to a larger absolute price distortion because the %-change in trade costs is levied over a larger base that includes the CIF-margin.

[22]The expansion effect is proportional to the NTM-related trade cost change. However, it is smaller than the substitution effect, which is governed by $\sigma > 1$. As a consequence, a reduction in iceberg trade costs generally increases trade volumes if opposite general equilibrium effects do not dominate.

berg trade cost, we distribute the total trade cost change ($\tilde{t}^s$) calculated in Equation (6) over the three mechanisms $\left\{\tilde{t}^{s,\tau}, \tilde{t}^{s,\text{imp}}, \tilde{t}^{s,\text{exp}}\right\}$ in the following way:

1. $\{\tilde{t}^{s,\tau}\}$: complete iceberg trade cost implementation.
2. $\left\{\tilde{t}^{s,\tau}, \tilde{t}^{s,\text{imp}}\right\}$: 50% iceberg trade costs and 50% rents on the importer side.
3. $\left\{\tilde{t}^{s,\tau}, \tilde{t}^{s,\text{imp}}, \tilde{t}^{s,\text{exp}}\right\}$: 50% iceberg trade costs and 50% rents of which regulatory differences are divided equally between the importer and exporter, and stringency-related rents accrue on the importer side.

Thus, when we allocate $\tilde{t}^s$ over $\left\{\tilde{t}^{s,\tau}, \tilde{t}^{s,\text{imp}}, \tilde{t}^{s,\text{exp}}\right\}$ we assume an equal split between the iceberg trade cost and trade tax mechanism. [23]

3 Results

This section presents results of the gravity estimations, corresponding AVE trade costs of regulatory changes between 2012 and 2017, as well as resulting trade and macroeconomic effects. We compare differences between a model that accounts for bilateral regulatory differences and regulatory stringency (HET) and a single indicator model (SI) for regulatory stringency. Unless stated otherwise, we distribute trade cost changes over iceberg trade cost, tariffs and export taxes.

3.1 Gravity estimations

Based on the sector-level estimations of Equations (1) and (2), Tables 1 and 2 present coefficients of the NTM variables and their interaction terms in Panel I, second stage coefficients for regulatory stringency in Panel II, and an evaluation of the total NTM effect (β^i) of Equation 3 in Panel III. The evaluation of β^i is conducted at different export-import-share bin combinations (see Section 2.2) and Panel III list the corresponding median and interquartile range of values significant at the 10% level. Additionally, we provide the NTM effect within PTAs for sectors with significant interaction effects of technical provisions and NTM variables.

[23] For a broader set of regulations and in the context of transatlantic trade, firm-level surveys indicate 60% trade cost increasing vs. 40% rent generating NTMs (CEPR, 2013). This distribution is also used by Jafari and Britz (2018) who further split the rent-generating component over 1/3 export and 2/3 import taxes.

We establish for the majority of sectors that a relative increase in harmonization versus divergence promotes trade, and find trade promoting and restricting effects of regulatory stringency. Thus, a reduction in bilateral regulatory differences results in a reduction of trade costs that is associated with compliance requirements exporting firms do not encounter on their respective home market. In contrast, the varying trade promoting and restricting effects common across all import sources (i.e. regulatory stringency) confirm previous studies (e.g. Beghin et al., 2015; Ghodsi, 2019) and suggest that technical measures combine trade cost and demand side effects resulting in an ambiguous net effect on trade. Regarding the magnitude of effects, we observe the largest elasticities of bilateral regulatory differences for automobile, transport, and electrical computer products, while the largest elasticities with respect to regulatory stringency are found for metal (products) and automobile products. Moreover, we obtain net trade promoting effects of regulatory stringency for machinery, metal products, chemicals, textile and light manufacturing products.

Larger trade shares reduce the positive trade effect of regulatory harmonization relative to divergence, reflecting that a high degree of market integration, inter alia, captures common regulatory preferences and/or conveys information about the importer's market power. Thus, exporters are more likely to possess adequate compliance capacity and/or importers are more likely able to pass on compliance costs to exporters. As a consequence, we observe a trade elasticity of bilateral regulatory differences that decreases with rising trade shares. Similarly, the trade restrictive effect of regulatory stringency mostly reduces with higher trade shares. In contrast, trade promoting effects of regulatory stringency are amplified or attenuated depending on the sector. This indicates that high market integration may resolve informational asymmetries, which reduces NTMs' trade promoting effects, or suggests that larger exporters may be able to better comply with trade promoting measures, respectively.

The interquartile ranges of estimates presented in Panel III of Tables 1 and 2 highlight that the sensitivity of regulatory differences with respect to trade share interactions is highest for automobile, electrical computers, machinery and grains, and lowest for textile, vegetables and fruits, and grains.

Table 1: Summary of gravity estimations I

	Grains	Veg & Fr	Crops	Animal	Extr Nrg	Fd Anm	Fd Plant	Tex	Lgt Mfc	Chem
Panel I: Main equation										
Dif	0.411 ***	0.155 **	0.612 ***	0.050	0.471	0.075	0.152 ***	-0.048	0.215	-0.141
	(0.131)	(0.067)	(0.188)	(0.141)	(0.468)	(0.080)	(0.046)	(0.223)	(0.358)	(0.177)
Dif*Msh	-0.023 ***	0.006	0.018	0.015	0.079 **	-0.003	-0.006	-0.009	-0.041 **	-0.006
	(0.009)	(0.006)	(0.014)	(0.010)	(0.034)	(0.006)	(0.004)	(0.009)	(0.020)	(0.012)
Dif*Xsh	0.020 **	-0.014 **	0.001	-0.008	-0.036	-0.002	0.002	-0.042 ***	-0.042 **	-0.010
	(0.009)	(0.006)	(0.020)	(0.010)	(0.034)	(0.007)	(0.005)	(0.009)	(0.017)	(0.010)
Dif*PTA Tech pre2012	-0.036	-0.079 ***	-0.141	0.081	0.458	0.084 **	0.006	-0.024	-0.547 **	0.154
	(0.068)	(0.024)	(0.103)	(0.085)	(0.315)	(0.042)	(0.023)	(0.109)	(0.246)	(0.100)
Dif*PTA Tech post2012	-0.061	-0.386 *	-0.111	1.319 **	-3.002	0.321	0.035	2.047 **	2.336	-0.244
	(0.530)	(0.200)	(0.548)	(0.673)	(4.184)	(0.215)	(0.059)	(0.876)	(2.094)	(0.570)
Border*Str	-0.011	0.005	0.168 ***	0.057	0.046	0.025	0.009	0.623 ***	0.609 ***	0.121 *
	(0.024)	(0.026)	(0.047)	(0.046)	(0.275)	(0.020)	(0.018)	(0.154)	(0.232)	(0.068)
Str*Msh	-0.007 **	0.001	0.022 ***	0.003	0.080 **	0.001	-0.000	0.003	0.015	0.015 *
	(0.003)	(0.003)	(0.006)	(0.004)	(0.033)	(0.003)	(0.002)	(0.011)	(0.022)	(0.008)
Str*Xsh	0.011 ***	0.003	0.009	0.005	-0.042	0.002	0.003	0.074 ***	0.055	-0.002
	(0.004)	(0.003)	(0.007)	(0.006)	(0.048)	(0.003)	(0.003)	(0.018)	(0.034)	(0.013)
Str*PTA Tech pre2012	0.034 *	-0.019 **	-0.002	-0.004	0.266	-0.001	0.011	-0.200 **	-0.356 ***	0.061 *
	(0.020)	(0.009)	(0.025)	(0.020)	(0.234)	(0.013)	(0.009)	(0.097)	(0.132)	(0.037)
Str*PTA Tech post2012	0.031	-0.156 *	-0.070	0.034	-3.431	0.018	0.003	2.455 ***	1.142	0.017
	(0.176)	(0.082)	(0.106)	(0.120)	(2.607)	(0.046)	(0.025)	(0.736)	(0.850)	(0.194)
Panel II: 2nd stage FE decomposition										
Str	0.036	0.004	0.024	-0.006	0.315	-0.058	-0.004	-0.018	-0.014	0.061 ***
	(0.111)	(0.012)	(0.030)	(0.060)	(0.312)	(0.058)	(0.004)	(0.053)	(0.054)	(0.022)
Panel III: Evaluation of NTM variables										
Dif Q2	0.45	0.22	0.47	–	–	0.11	0.18	0.39	0.76	–
Dif IRQ	0.15	0.05	0.05	–	–	0.01	0.01	0.03	0.13	–
Str Q2	–	–	-0.09	–	–	–	-0.02	0.24	0.23	0.11
Str IRQ	–	–	0.05	–	–	–	0.01	0.12	0.07	0.03
Dif PTA Q2	–	0.14	–	–	–	–	–	0.39	–	–
Str PTA Q2	–	-0.04	–	–	–	–	–	-0.30	-0.33	–

Note: 1) See complete results in Appendix F. 2) Xsh/Msh: exporter/importer share. 3) Panel III: Significance of total NTM-effect (β^i) evaluated for 100 midpoints of export-import-share bin combinations (bootstrapped standard errors, 200 replications).

Table 2: Summary of gravity estimations II

	Pharma	Plastics	Mineral	Metal	Metal pr	El Comp	El Eq	Machine	Transport	Auto
Panel I: Main equation										
Dif	-0.256	-0.202	-0.534	-0.714	2.794 ***	0.313	-0.021	0.308 **	1.011	0.569 *
	(0.200)	(0.212)	(0.410)	(0.666)	(0.532)	(0.278)	(0.184)	(0.153)	(0.657)	(0.302)
Dif*Msh	-0.051 ***	-0.033 ***	-0.022	-0.025	-0.027	-0.063 ***	-0.024 *	-0.008	-0.076 **	-0.116 ***
	(0.015)	(0.012)	(0.020)	(0.023)	(0.018)	(0.018)	(0.013)	(0.008)	(0.030)	(0.025)
Dif*Xsh	-0.002	-0.017	-0.010	-0.018	-0.020	-0.049 ***	-0.019 **	-0.012	0.017	0.002
	(0.018)	(0.014)	(0.019)	(0.021)	(0.019)	(0.012)	(0.010)	(0.009)	(0.039)	(0.033)
Dif*PTA Tech pre2012	-0.159	0.009	-0.003	0.664	0.043	-0.366 *	-0.259 ***	-0.056	-0.326	-0.214
	(0.164)	(0.178)	(0.504)	(0.511)	(0.368)	(0.188)	(0.081)	(0.081)	(0.367)	(0.167)
Dif*PTA Tech post2012	0.506	0.782	-1.469	0.292	5.060	-0.032	-0.255	0.365	3.083	0.087
	(1.019)	(0.858)	(4.045)	(2.746)	(5.231)	(2.048)	(0.537)	(0.330)	(4.746)	(0.964)
Border*Str	-0.166 **	0.060	-0.261	0.046	0.889 ***	0.271 ***	-0.005	0.033	1.514 ***	-0.105
	(0.071)	(0.106)	(0.333)	(0.248)	(0.249)	(0.053)	(0.056)	(0.048)	(0.367)	(0.105)
Str*Msh	0.008	-0.020 **	-0.020	0.034 *	-0.046 ***	0.008	-0.006	-0.009 ***	-0.022	-0.003
	(0.008)	(0.010)	(0.018)	(0.018)	(0.016)	(0.006)	(0.005)	(0.003)	(0.027)	(0.011)
Str*Xsh	-0.025 **	0.027 *	-0.005	0.123 ***	0.004	0.034 ***	0.013	0.008	0.241 ***	-0.031
	(0.010)	(0.015)	(0.034)	(0.029)	(0.023)	(0.010)	(0.008)	(0.006)	(0.064)	(0.023)
Str*PTA Tech pre2012	-0.043	0.005	-0.046	0.313	-0.020	-0.200 ***	-0.115 ***	-0.039	-0.184	-0.016
	(0.028)	(0.087)	(0.363)	(0.261)	(0.200)	(0.057)	(0.028)	(0.032)	(0.227)	(0.060)
Str*PTA Tech post2012	0.166	0.541	-0.663	1.078	3.367	0.184	-0.023	0.366 *	2.118	0.039
	(0.223)	(0.524)	(2.531)	(1.590)	(3.093)	(0.711)	(0.377)	(0.205)	(2.579)	(0.233)
Panel II: 2nd stage FE decomposition										
Str	0.087	-0.125 **	-0.106	0.175	0.009	0.084	-0.016	-0.022	-0.048	-0.532 *
	(0.092)	(0.060)	(0.130)	(0.150)	(0.147)	(0.142)	(0.017)	(0.020)	(1.119)	(0.300)
Panel III: Evaluation of NTM variables										
Dif Q2	0.35	–	–	–	3.13	1.09	0.3	0.45	1.43	1.45
Dif IRQ	0	–	–	–	0.09	0.28	0.07	0.04	0.28	0.52
Str Q2	–	-0.2	–	-0.81	1.2	–	-0.07	0.06	–	-0.5
Str IRQ	–	0.03	–	0.31	0.14	–	0.03	0.02	–	0.01
Dif PTA Q2	–	–	–	–	–	0.76	–	–	–	–
Str PTA Q2	–	–	–	–	–	–	-0.17	–	–	–

Note: 1) See complete results in Appendix F. 2) Xsh/Msh: exporter/importer share. 3) Panel III: Significance of total NTM-effect (β^i) evaluated for 100 midpoints of export-import-share bin combinations (bootstrapped standard errors, 200 replications).

For regulatory stringency, we find the highest sensitivity for textiles, metal, and metal products with other sectors relatively unaffected by trade share interactions.[24]

Furthermore, significant interaction effects of technical PTA provisions with NTM-related trade costs is limited to relatively few sectors – vegetables & fruits, textiles, light manufacturing, and electrical equipment and computers. With the exception of vegetables & fruits and textiles this effect is limited to PTAs in force before 2012, which suggests that technical provisions require a phase-in period before developing an effect on trade.

Without controlling for bilateral regulatory differences the trade cost effect of regulatory divergence is likely captured by the regulatory stringency indicator. Across most sectors, the impact of regulatory stringency on trade tends to be less restrictive when we control for bilateral regulatory differences compared to the effect of regulatory stringency in the single indicator model. This demonstrates that N_d^{str} captures part of the trade cost effect implied by regulatory divergence, which is a component of N_{od}^{dif} (Vogt, 2022; Xiong and Beghin, 2014). In our context, the attribution of trade cost changes to the correct NTM dimension is particularly relevant because bilateral variation in regulatory differences (N_Δ^{dif}) leads to different trade cost changes compared to destination-specific variation in regulatory stringency (N_Δ^{str}).[25]

For most sectors we select instruments that capture historical ties or represent cultural similarities – i.e. same colonizer ever, common legal background pre transition, same country ever, and common religion for 14, 11, 10, 10 sectors, respectively. Other instruments, with the number of sectors in brackets, are: colonial relationship after 1945 (8), colonial dependency ever (8), common official language (6), time difference (5), common colonizer after 1945 (5), common legal background post transition (2), and difference in latitude (1). Moreover, we instrument with at least three variables in each of the three first stage equations presented in Section 2.1.[26]

[24]Note that high elasticities in manufacturing sectors may be the outcome of lower variation in the underlying NTM indicators compared to agri-food products. Agri-food products are highly regulated by SPS and TBT measures. By contrast, SPS measures are hardly imposed on manufactures. This results in a higher standard deviation of e.g. the average number of measures per product (regulatory stringency) – 12.6 vs. 2.7 for agri-food and manufactures, respectively.

[25]See Table 16 in Appendix F for a comparison of NTM elasticities of the heterogeneous effects and single indicator model.

[26]An overview of statistics of the tests of joint significance and selection of instruments by sector is presented in Appendix E.

3.2 Regulation-induced trade cost changes

Based on the elasticities obtained by the gravity regressions we transform 2012 to 2017 changes in bilateral regulatory differences and regulatory stringency into AVE trade cost changes ($\tilde{t}^{s}_{od}$ determined by Equation (6)). Table 3 presents sectoral averages of the NTM indicators in 2017, as well as their percentage change from 2012 to 2017. As demonstrated in Tables 1 and 2, the NTM-effect is insignificant for some sectors and differs across importer-exporter-share combinations. Consequently, not all regulatory changes that take place between 2012 and 2017 necessarily result in trade cost changes. Thus, Table 3 differentiates between those baseline values and changes that lead to trade cost changes (Panel II) versus averages across all observations (Panel I). By this, we assess whether regulatory changes relevant for our trade cost estimates are representative for changes across all country pairs.

Our analysis covers increases in regulatory stringency ranging from approximately 4% to 21%, which is similar to the range of regulatory changes across all observations. In manufacturing sectors the introduction of new measure types leads to relatively more divergence, which is

Table 3: Changes in regulation 2012 to 2017

	(I) All				*(II) Basis for TC changes*			
	Baseline 2017		%-change		Baseline 2017		%-change	
	Str	Dif	Str	Dif	Str	Dif	Str	Dif
Grains	18.67	-2.04	15.41	8.63	–	-2.22	–	11.59
Veg & Fruits	17.14	-1.60	15.26	19.68	23.57	-1.75	21.28	23.75
Crops	8.86	-1.31	14.55	8.76	8.76	-1.40	21.82	10.14
Animal	10.68	-1.22	11.81	6.75	–	–	–	–
Extr Nrg	0.99	-0.61	17.66	-4.81	–	–	–	–
Food Anm	18.58	-1.38	11.81	25.52	–	-1.39	–	31.31
Food Plant	14.28	-1.86	14.76	14.59	16.32	-1.90	17.13	16.44
Tex	1.33	-0.72	3.62	-5.17	1.85	-0.82	4.17	-7.63
Light Mfc	1.27	-0.59	9.30	-6.24	1.62	-0.72	12.19	-7.40
Chem	2.26	-1.02	17.50	-4.75	3.13	–	19.43	–
Pharma	5.35	-1.37	21.85	-0.41	–	-1.01	–	19.84
Plastics	1.32	-0.63	7.92	-3.93	2.69	–	9.61	–
Mineral	0.82	-0.49	5.91	-7.49	–	–	–	–
Metal	0.56	-0.34	9.76	-5.39	0.98	–	13.05	–
Metal products	0.68	-0.41	5.56	-3.90	1.19	-0.72	8.01	-5.42
Electr Comp	1.33	-0.58	9.71	-4.57	–	-0.74	–	-5.79
Electr Eq	1.92	-0.81	5.71	-1.96	3.23	-1.05	7.25	-2.34
Machinery	1.33	-0.69	4.51	-3.71	3.20	-1.10	4.45	-4.72
Transport	0.88	-0.51	7.72	-2.09	–	-0.83	–	-3.29
Auto	2.19	-0.74	6.81	-0.26	2.75	-0.93	9.64	-0.39

Note: 1) Str are the average number of measures per product in a given sector. 2) Dif are average harmonization minus divergence events.

demonstrated by the negative changes in regulatory differences.[27] By contrast, relatively high regulatory activity in agri-food sectors results in an increase in harmonized versus divergent measure. A comparison of baseline averages and changes presented in Panel I and Panel II highlights that observations affected by trade cost changes are characterized by a higher NTM incidence in 2017, and larger 2012 to 2017 changes in stringency, harmonization and divergence. However, the direction of regulatory change is the same in both panels, which shows that on average our analysis covers general developments in NTMs. Importantly, regulatory trends are heterogeneous across sectors implying that e.g. homogeneous shocks in ex-ante simulations are likely to ignore significant sectoral differences.

We translate regulatory changes from 2012 to 2017 presented in Panel II of Table 3 into trade cost changes. Table 4 shows these (trade-weighted) trade cost changes for imports, differentiated by NTM dimension, region and sector.[28] In total, NTM-related trade costs decrease

Table 4: Trade-weighted trade cost changes by sector (All – HET, in %)

	Dif	Str	All	EAP	ECA	LAC	MENA	NA	SA	SSA
Grains	-4.55	–	-4.55	-2.28	-23.29	0.23	-4.03	-6.15	-14.55	-2.45
Veg & Fruits	-9.59	2.54	-7.06	-8.56	-15.95	-0.94	-12.65	4.10	-12.96	-7.31
Crops	-2.09	-9.36	-11.31	-16.75	-8.86	-1.20	-8.30	1.87	-6.37	-2.43
Animal	–	–	–	–	–	–	–	–	–	–
Extr Nrg	–	–	–	–	–	–	–	–	–	–
Food Anm	-0.52	–	-0.52	-0.02	-0.99	-2.66	0.32	-1.15	1.46	0.23
Food Plant	-8.91	1.82	-7.05	-6.90	-13.69	-4.62	-10.53	-0.76	-13.26	-4.18
Tex	0.02	-0.13	-0.10	-0.01	-0.39	-0.04	-0.01	0.09	-0.03	-0.05
Light Mfc	0.25	-0.24	0.01	-0.41	1.29	0.21	-0.14	-0.59	-0.22	-0.10
Chem	–	-1.04	-1.04	-1.35	-0.90	-0.72	-0.44	-1.27	-0.13	-0.25
Pharma	0.00	–	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plastics	–	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Mineral	–	–	–	–	–	–	–	–	–	–
Metal	–	0.32	0.32	0.40	0.57	0.14	0.00	0.06	0.11	0.10
Metal products	-0.58	-1.47	-2.02	-3.24	-0.73	-0.13	-0.71	-3.42	-1.16	-0.46
Electr Comp	-1.00	–	-1.00	-1.16	0.04	-0.10	-0.30	-1.75	-1.37	-0.57
Electr Eq	-0.02	0.35	0.33	0.10	0.62	0.40	-0.02	0.47	0.00	-0.37
Machinery	-0.42	0.00	-0.42	-0.78	-0.19	-0.12	-0.08	-0.31	-0.66	-0.19
Transport	-0.40	–	-0.40	0.21	-2.18	0.50	0.22	-0.11	-0.06	-0.06
Auto	-1.05	1.76	0.72	-0.54	-2.13	1.04	-0.64	2.71	-0.46	0.00
Total	-0.76	0.05	-0.71	-1.05	-0.93	-0.17	-0.96	-0.01	-1.08	-0.63

Note: 1.) Trade cost changes calculated for imports. 2.) Dif, Str, and All are trade cost changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1).

[27] For example, automobile's regulatory difference indicator equals -0.93 in base year 2017, i.e. on average destination countries impose one more additional measure type not imposed in origin countries, relative to the average number of harmonized measure types. We model a 0.39% reduction in the regulatory difference indicator from 2012 to 2017. This corresponds to a decrease in harmonized relative to divergent measures of 0.00363 reflecting a presumably trade restricting regulatory change during these years.

[28] Throughout this study we present results by the following regions: East Asia & Pacific (EAP), Europe & Central Asia (ECA), Latin America & Caribbean (LAC), Middle East & North Africa (MENA), North America (NA), South Asia (SA), and Sub-Saharan Africa (SSA). These are aggregated from the individual country-level.

by a tariff-equivalent of 0.71% of which changes in bilateral regulatory differences and stringency contribute with a reduction of 0.76% and increase of 0.05%, respectively (see columns Dif, Str, and All). Trade cost changes vary considerably across regions and sectors. We find significant trade cost reductions for crops, vegetables and fruits, as well as plant-based food products ranging from 7% to 11%. Trade cost reductions of vegetables and fruits, and plant-based food products are caused by harmonization effects that outweigh costs associated with regulatory stringency and divergence, while for crops trade-promoting effects of more stringent standard-like regulation drive decreases in trade costs. Moreover, manufacturing sectors experience positive as well as negative trade cost effects. While on average regulatory divergence increases relative to harmonization, trade-weighted trade cost reductions based on bilateral regulatory differences (Column Dif) highlight that countries trading more intensely in manufactures harmonize technical measure with each other to a higher degree than with other countries. In addition, trade-promoting effects explain part of the trade cost reductions for metal products, chemicals, textiles, and light manufacturing. On the regional level, we observe the largest trade cost reductions for East-Asia & Pacific, and Europe & Central Asia, Middle East & North Africa and South Asia, and the lowest trade cost changes for countries on the American continent. This difference is caused by lower harmonization of Latin American & Caribbean and North American imports of agri-food products compared to other regions, and by divergence and stringency-related trade cost increases for automobile imports.

Estimating NTM-related trade cost changes without accounting for bilateral regulatory differences underestimates global trade cost reductions due to harmonization trends between 2012 and 2017. Instead of a tariff-equivalent reduction of 0.71%, trade costs derived from the single indicator model increase by 0.11%. Table 5 maps trade-weighted trade cost changes into two matrices of regions and income levels. Panel I and II exhibit total trade cost changes that are based on the heterogeneous NTM effect and single indicator model, respectively. Intra- and inter-regional trade cost changes are equally heterogeneous and strongly depend on changes in the bilateral regulatory difference indicator. An increase in regulatory harmonization relative to divergence reduces export costs of low and lower middle income countries by 1.5%. Particularly, poorer countries in East Asia & Pacific and Middle East & North Africa benefit from these regulatory developments, while Sub-Saharan African countries' export cost actually increase between 2012 and 2017. As shown in Table 4, these effects are mainly caused by NTM-related trade cost developments in agri-food sectors. Moreover, despite the fact that export costs of

Latin American & Caribbean countries exhibit the highest cost reductions across most markets, increasing market access costs for intra-regional trade, as well as for North America, result in an overall modest trade cost reduction. By contrast, regulatory changes faced and imposed by East Asia & Pacific countries lead to further integration into the world economy as their import and export costs drop across almost all regions for agri-food and manufacturing sectors alike. A comparison of Panel I and II confirms that it is highly relevant to account for bilateral regulatory differences because most of the apparent heterogeneity in trade cost changes presented in Panel I is missing for trade cost changes derived from a single indicator model displayed in Panel II.

Table 5: Trade-weighted trade cost changes by region/income (All – HET vs. Str – SI, in %)

	High	UM	LM	Low	EAP	ECA	LAC	MENA	NA	SA	SSA	Total
Panel I: All – HET												
High	-0.23	-0.56	-0.48	-0.31	-0.54	-0.40	-0.11	-0.85	0.05	-0.53	-0.47	-0.37
UM	-0.78	-1.72	-1.32	-1.05	-1.88	-1.26	-0.20	-1.16	-0.06	-1.13	-0.85	-1.03
LM	-1.18	-1.89	-2.85	0.30	-1.84	-1.84	-0.64	-1.06	-0.21	-3.28	-0.68	-1.52
Low	-2.82	1.06	-1.03	2.23	0.32	-3.29	0.25	-2.08	-1.21	-0.82	0.78	-1.54
EAP	-1.31	-1.00	-1.38	-0.54	-1.22	-1.59	-0.47	-1.01	-1.10	-1.75	-0.78	-1.23
ECA	-0.33	-0.86	-0.52	-1.08	-0.53	-0.38	-0.24	-0.72	-0.67	-0.68	-0.54	-0.52
LAC	0.64	-2.38	-2.04	2.69	-2.93	-4.01	0.28	-4.66	1.99	-2.07	-5.21	-0.33
MENA	-0.24	-0.13	-0.05	-0.21	-0.04	-0.32	-0.23	-1.07	0.15	-0.03	-0.42	-0.19
NA	-0.01	-0.85	-1.50	-0.85	-1.59	-0.50	-0.14	-1.04	0.68	-2.17	-0.93	-0.34
SA	-0.15	-0.16	0.32	0.49	0.33	-0.26	0.21	-0.16	-0.38	-0.09	0.92	-0.08
SSA	0.46	1.41	0.24	0.60	1.79	0.45	0.97	-0.89	1.25	-0.08	0.13	0.56
Total	-0.54	-0.97	-1.02	-0.40	-1.05	-0.93	-0.17	-0.96	-0.01	-1.08	-0.63	-0.71
Panel II: Str – SI												
High	0.13	0.02	0.15	0.22	0.10	0.11	0.11	0.11	0.07	0.03	0.09	0.09
UM	0.17	0.03	0.17	0.30	0.09	0.22	0.09	0.14	0.17	0.07	0.14	0.15
LM	0.12	-0.02	0.28	0.31	0.09	0.12	0.23	0.06	0.07	0.11	0.30	0.10
Low	0.08	-0.01	0.02	0.04	0.00	0.07	0.12	0.09	-0.03	0.02	0.05	0.05
EAP	0.18	-0.02	0.08	0.32	0.02	0.30	0.06	0.06	0.20	0.05	0.15	0.11
ECA	0.07	0.05	0.17	0.31	0.15	0.07	0.10	0.12	-0.04	0.04	0.11	0.08
LAC	0.28	0.24	1.19	0.99	0.57	0.45	0.23	1.00	0.18	0.34	0.29	0.32
MENA	0.03	-0.12	0.00	0.16	-0.05	0.06	-0.23	0.06	-0.01	0.00	0.09	0.00
NA	0.19	0.03	0.36	0.11	0.31	0.10	0.12	0.09	0.09	0.03	0.05	0.15
SA	0.01	-0.14	0.61	0.27	0.23	-0.03	-0.14	0.06	-0.03	0.02	0.36	0.05
SSA	0.04	0.00	0.01	0.01	0.02	0.05	-0.02	0.05	0.00	0.00	0.01	0.03
Total	0.14	0.02	0.17	0.27	0.10	0.16	0.11	0.12	0.11	0.05	0.14	0.11

Note: 1.) Panel I: All – HET are trade cost changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). We sum trade cost changes caused by changes in regulatory stringency and difference. Panel II: Str – SI are trade cost changes based on regulatory stringency in the single indicator (SI) model, i.e. we exclude bilateral regulatory differences from Equation (1). 2) Table 21 in Appendix I provides a detailed overview of trade cost changes by importing and exporting country, and NTM dimension.

3.3 Trade effects in general equilibrium

We assess the general equilibrium effect of NTM-related trade cost changes from 2012 and 2017 on aggregate and sectoral trade flows. The presentation of results differentiates between trade flow changes between income levels as defined by the World Bank for 2017 and geographic regions, and highlights differences with respect to outcomes based on the heterogeneous effect or single indicator specification of the gravity model.[29] Furthermore, we compare changes in bilateral trade flows generated by the general equilibrium model vs. partial equilibrium predictions.

Modeling NTM-related trade cost changes of bilateral regulatory differences leads to significantly different changes in trade patterns compared to the single indicator model that does not differentiate between multiple NTM effects. This is depicted by Table 6, which juxtaposes percentage changes in trade patterns between regions and income levels for each of the modeling approaches – i.e. Panel I: heterogeneous NTM effects vs. Panel II: single indicator model. With respect to changes in stringency-related trade costs in a single indicator model, Panel II shows that global trade flows decrease modestly by 0.18%, which demonstrates that trade cost effects dominate trade-promoting effects associated with technical measures. This effect is also observable for regulatory stringency in the heterogeneous effect model, although to a lesser degree indicating that bilateral regulatory differences capture part of the trade cost effect dominating in the single indicator model (see Appendix J). Moreover, Panel I establishes that global trade increases by 0.16% once we explicitly model trade cost changes due to regulatory harmonization and divergence over 2012 to 2017. Differences in trade flow changes between Panel I and II are explained by two drivers. First, positive trade effects of regulatory similarity identified in the gravity regressions in combination with an increase in regulatory similarity (cf. Table 3) lead to trade cost reductions. Second, stronger trade-promoting effects of regulatory stringency are identified for most sectors once trade cost effects are (partially) absorbed by bilateral regulatory differences.[30] In total, 0.16% correspond to a gain in global trade volume of USD 23 billion of which USD 7.4 billion are diversion effects representing ca. 25% of total direct effects.[31]

[29] For a mapping of countries to income groups and geographic regions see Appendix B.

[30] See Appendix J presenting results for separate simulations of trade cost changes of regulatory stringency and structure.

[31] Direct/Indirect effects are defined as changes in trade flows affected/unaffected by trade cost changes. See Appendix J for an overview of direct and indirect trade volume effects by region, income-level and broad sectors.

With respect to income level, the top-left quadrant and corresponding totals in the last row (imports) and column (exports) of Panel I demonstrate that particularly middle-income countries integrate into the world economy as a result of regulatory changes between 2012 and 2017, while total imports and exports of high- and low-income countries remain relatively unchanged. Low-income countries shift exports from upper-middle- and other low-income countries to high- and lower-middle-income countries resulting in slight overall decrease of 0.05%. Their total imports increase by 0.43%, which is driven by higher import volumes from upper-middle-income countries. In addition, regulatory changes contributed positively to higher imports and exports of middle-income countries ranging from 0.31% to 0.75%. These gains are to a large degree due to growing trade between middle-income countries. Moreover, high-income countries increase their imports from low-income countries by 2.12% and integrate with upper-middle income countries, i.e. imports and exports increase by 0.42% and 0.46%, respectively.

On the regional level, the bottom-right quadrant and corresponding totals in the last row (imports) and column (exports) of Panel I show that regulatory developments lead to notable changes in trade for most regions, highlighting the relevance to assess these policy changes on a global level. Particularly, we observe regulation-induced shifts in trade pattern towards a more central role in the global trading environment of East Asia Pacific, Europe & Central Asia, as well as South Asia. Their imports and exports grow by 0.5 to 1.2% due to a reduction in bilateral regulatory differences and an increase in regulation in sectors with trade-promoting NTM effects (cf. changes in trade for regulatory stringency in Table 22 – Appendix J). Latin America & Caribbean countries and North America reorient trade away from the Americas towards overseas markets. However, while North America's reduction in market access costs leads to higher imports from East Asia & Pacific, Europe & Central Asia, and South Asia, Latin America & Caribbean countries' changes in regulation result in lower imports from all regions. This shows that relative changes in market access matter because regulatory changes between 2012 and 2017 decreased market access costs to Latin America & Caribbean countries for some regions. However, these trade cost reductions are relatively small compared to alternative export markets. In addition, integrating with oversea markets at the cost of diverging from important existing trade partners (i.e. Latin America & Caribbean and North America) may lead to an overall decrease in trade because increasing trade costs apply to larger trade volumes. Finally, regulatory integration of Sub-Saharan Africa with neighboring Middle East

Table 6: Changes in trade by region/income (All – HET vs. Str – SI, in %)

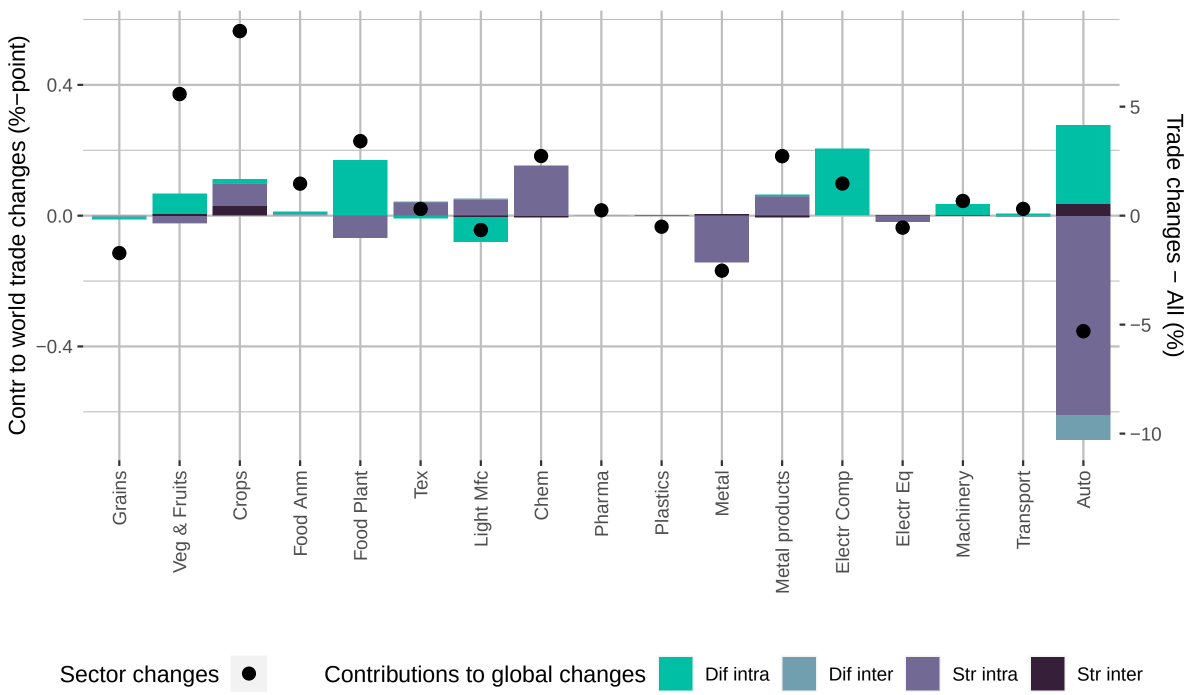
	High	UM	LM	Low	EAP	ECA	LAC	MENA	NA	SA	SSA	Total
Panel I: All – HET												
High	-0.47	0.46	-0.26	0.40	0.85	0.13	-2.66	0.38	-1.39	0.19	-0.32	-0.16
UM	0.42	1.45	0.67	0.76	2.03	1.65	-1.53	-0.15	-1.16	0.35	-0.45	0.65
LM	-0.02	1.31	2.39	0.13	0.89	0.89	-1.21	0.69	-0.97	2.68	0.44	0.55
Low	2.12	-7.91	1.57	-2.89	-6.97	2.60	-1.94	3.21	-0.30	0.81	-0.92	-0.05
EAP	1.33	0.95	0.14	0.11	0.96	2.28	-1.05	0.34	1.13	0.64	-0.78	1.06
ECA	0.25	1.72	-0.03	0.79	1.76	0.09	-1.15	-0.09	1.14	0.07	-0.28	0.66
LAC	-3.27	1.29	2.33	-3.25	2.32	2.44	-1.89	1.67	-5.28	1.82	2.65	-1.78
MENA	-0.19	0.44	-0.07	1.00	0.09	-0.37	-0.86	1.10	-0.60	-0.03	0.24	-0.03
NA	-2.05	-1.09	1.01	1.30	1.80	-0.19	-3.77	0.27	-5.09	1.56	0.16	-1.62
SA	0.94	0.13	0.89	-0.12	0.25	1.42	-1.13	0.14	1.32	0.55	-0.49	0.77
SSA	-0.40	-3.16	1.05	0.85	-2.87	-0.29	-1.54	2.15	-1.42	0.75	0.66	-0.49
Total	-0.11	0.75	0.31	0.43	1.17	0.79	-2.26	0.30	-1.27	0.54	-0.27	0.16
Panel II: Str – SI												
High	-0.23	-0.21	-0.23	-0.24	-0.24	-0.25	-0.41	-0.10	-0.15	-0.07	-0.15	-0.22
UM	-0.15	-0.01	0.05	-0.03	0.06	-0.31	-0.07	0.07	-0.13	0.11	0.00	-0.10
LM	-0.25	0.09	-0.14	-0.31	-0.16	-0.10	-0.45	-0.10	-0.23	-0.01	-0.32	-0.16
Low	-0.34	-0.16	0.09	0.07	-0.12	-0.42	-0.46	-0.27	-0.03	0.06	-0.05	-0.21
EAP	-0.25	0.05	0.04	-0.04	0.02	-0.45	-0.16	0.11	-0.32	0.13	-0.01	-0.13
ECA	-0.16	-0.50	-0.32	-0.41	-0.52	-0.21	-0.54	-0.17	-0.01	-0.31	-0.27	-0.27
LAC	-0.24	-0.35	-0.88	-0.01	-0.64	-0.58	-0.23	-0.54	-0.10	-0.12	0.16	-0.30
MENA	-0.11	0.11	-0.06	-0.11	0.00	-0.13	-0.24	-0.02	-0.09	-0.01	-0.14	-0.05
NA	-0.23	-0.04	-0.28	0.02	-0.24	-0.13	-0.37	0.05	-0.10	0.03	-0.01	-0.18
SA	-0.02	0.25	-0.25	-0.28	-0.24	0.15	0.21	-0.06	0.00	0.15	-0.31	0.00
SSA	-0.13	-0.16	0.02	0.04	-0.14	-0.12	-0.29	-0.18	-0.01	-0.03	0.01	-0.10
Total	-0.20	-0.14	-0.12	-0.18	-0.15	-0.26	-0.31	-0.06	-0.15	-0.01	-0.12	-0.18

Note: 1) Panel I: All – HET are trade flow changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). We sum trade cost changes caused by changes in regulatory stringency and difference. Panel II: Str – SI are trade flow changes based on regulatory stringency in the single indicator (SI) model, i.e. we exclude bilateral regulatory differences from Equation (1).

& North Africa, as well as with population-rich South Asia results in a notable increase in exports of 2.15% and 0.75%.

Globally, regulatory changes most significantly affect trade in agri-food and metal products, as well as chemical and motor vehicle sectors. The most important sectors in terms of their trade cost changes' contribution to shifts in world exports are chemicals, electrical components, motor vehicles, and plant-based foods. Figure 1 highlights these results by presenting sector-level changes in exports and their contribution to total, global changes in exports for different NTM trade cost dimensions. Contributions to world export changes are differentiated between intra-sectoral, i.e. how trade cost changes in a sector contribute to trade changes in that sector, and inter-sectoral, spillover effects, i.e. how trade cost changes in a sector contribute to trade changes in other sectors (e.g. the effect of regulatory changes in chemicals on exports in

Figure 1: %-changes sector trade and contributions to world trade changes

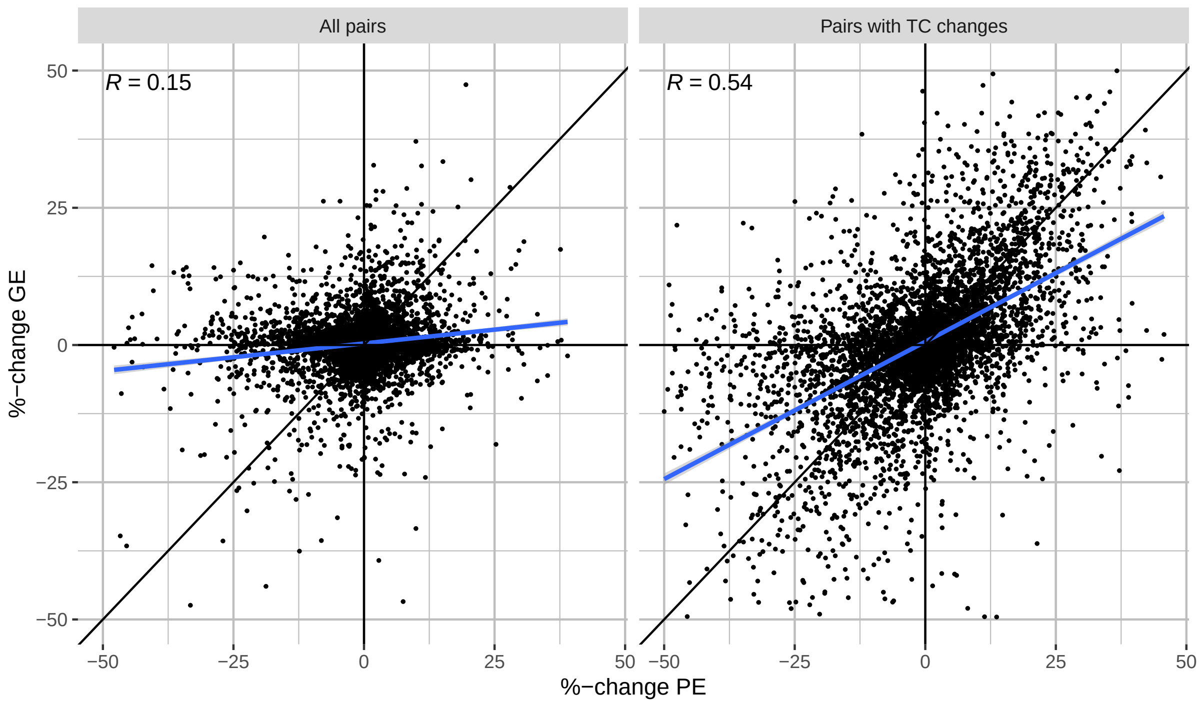


Note: 1) Results based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). We sum trade cost changes caused by changes in regulatory stringency and difference. 2) Total trade flows by sector are represented by black dots with the secondary/right y-axis as reference. 3) Contributions of percentage-points to global trade flow changes represented by bars with primary/left y-axis as reference.

motor vehicles). Summing over all bars in Figure 1 results in the total increase in world trade volumes of 0.16% presented in Panel I of Table 6. The separate scenario for stringency-related trade cost changes demonstrates that trade-promoting demand-side effects in chemicals, light manufacturing, as well as metal products significantly contribute to overall changes in exports. Except for chemical products, this effect is not captured by the single indicator model. The relatively large impact of these sectors is caused by high regulatory activity during the five years under investigation. Additionally, particularly for these sectors, the trade-promoting effect operates predominantly between country pairs with higher trade shares. Thus, trade cost changes affect relatively large trade flows. Furthermore, spillover effects tend have the opposite effect compared to intra-sectoral trade cost changes, which highlights cross-sectoral trade diversion effects – e.g. positive contribution to global trade of intra-sectoral trade flow changes in motor vehicles induced by harmonization (0.24 percentage-points) vs. the negative effect of the inter-sectoral counterpart (ca. 0.08 percentage-points).

General equilibrium effects of trade flow changes are significantly larger compared to partial equilibrium predictions of the gravity equation, which demonstrates that inter-sectoral linkages and adjustment to trade cost changes through factor prices (e.g. wages) are relevant for evaluating regulatory changes. Figure 2 compares general equilibrium changes in trade flows with their partial equilibrium counterparts. On the left-hand side we average over all pairwise sectoral trade flows, while on the right-hand side we average only over pairwise sectoral trade flows that are subject to a trade cost change. Across all sectors, 43% of bilateral trade flows are affected by such changes. There is a strong positive correlation (correlation coefficient 0.54) of general and partial equilibrium trade flow changes if we include only affected trade flows. This correlation is significantly lower if we compare partial and general equilibrium trade flows changes across all pairs because averages of all country-pair-sector combinations are influenced by zero and very small changes in partial and general equilibrium, respectively. These findings are in line with the comparative analysis of Bekkers and Rojas-Romagosa (2019), who show that inter-sectoral linkages and mobile factors of production lead to relatively larger trade and welfare effects.

Figure 2: %-changes total bilateral trade flows – PE vs. GE



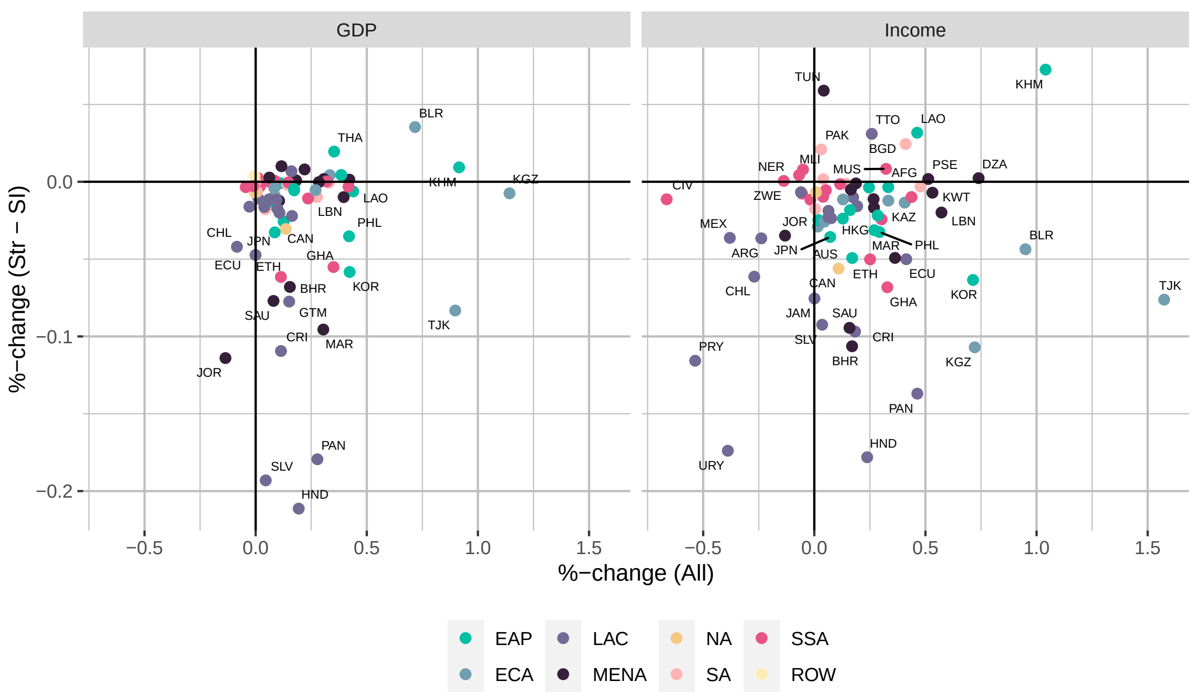
Note: 1) Trade flow changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). We sum trade cost changes caused by changes in regulatory stringency and difference. 2) The right-hand side presents changes in total bilateral trade averaged over all bilateral sectoral trade flows. 3) The left-hand side presents changes in total bilateral trade averaged over bilateral sectoral trade flows affected by a trade cost (TC) change. 4) Observations outside the [−50, 50] interval excluded. 5) R is the correlation coefficient.

3.4 Macroeconomic effects

Changes in regulation-induced trade costs between 2012 and 2017 and the corresponding changes in trade patterns lead to heterogeneous macroeconomic effects. Figure 3 compares changes in real GDP and income by country across the same two scenarios presented in Panel I and II of Tables 5 and 6, i.e. the effect of trade cost changes based on the heterogeneous effect model that accounts for bilateral regulatory differences versus the effect of regulatory stringency-related trade cost changes based on the single indicator specification of the gravity equation.

Regulatory changes lead to real GDP and income gains for most countries ranging from 0 to 0.5% and 0 to 0.1% in the heterogeneous effects and single indicator model, respectively. The magnitude and direction of macroeconomic effects follow the changes in trade shown in Table 6, with the negative correlation demonstrating the importance of properly identifying bilateral trade cost changes and trade-promoting effects of technical NTMs. Particularly, economies in

Figure 3: Changes in real GDP and income (in %)



Note: 1) x-axis: All – HET are real GDP and income changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). We sum trade cost changes caused by changes in regulatory stringency and difference. y-axis: Str – SI are real GDP and income changes based on regulatory stringency in the single indicator (SI) model, i.e. we exclude bilateral regulatory differences from Equation (1) 2) BEN, NIC, NZL, VNM removed for exposition. Full country-level real income results in Table 24 – Appendix K.

Central Asia (Kyrgyzstan, Belarus, Tajikistan), Middle East & North Africa (Lebanon, Algeria, Kuwait), as well as East Asia & Pacific (Cambodia, Korea, Laos) benefit from regulatory changes. By contrast, some countries in Latin America (e.g. Paraguay, Uruguay, Chile) experience real income losses, while most of Sub-Saharan Africa stagnate. This shows that regulatory reform such as changes in technical regulation can have unintended economic welfare effects (e.g. in the form of real income changes) via the trade cost channel. These effects may be positive if technical regulation on the home market resembles those imposed on main export markets.

In Table 7 we list changes in real income by region and income group for multiple scenarios and NTM-related trade cost dimensions. The distribution of trade cost changes over iceberg trade costs and import and export taxes does not affect the pattern of real income effects across regions and income groups. Generally, modeling regulatory changes as iceberg trade costs results in larger income effects, which is consistent with efficiency gains (expansion effect) associated with a reduction in iceberg trade costs. Moreover, changes in bilateral regulatory differences contribute more to total results than changes in regulatory stringency. For example, for the full iceberg trade cost scenario changes in regulatory differences and stringency add 0.21 and 0.01 percentage points to the total effect of 0.22%, respectively.

Real income effects range from 0.09 to 0.25 for different income groups, although there is significant heterogeneity across countries as shown in Figure 3. While all country groups

Table 7: Sensitivity analysis: Change in real income by scenario (in %)

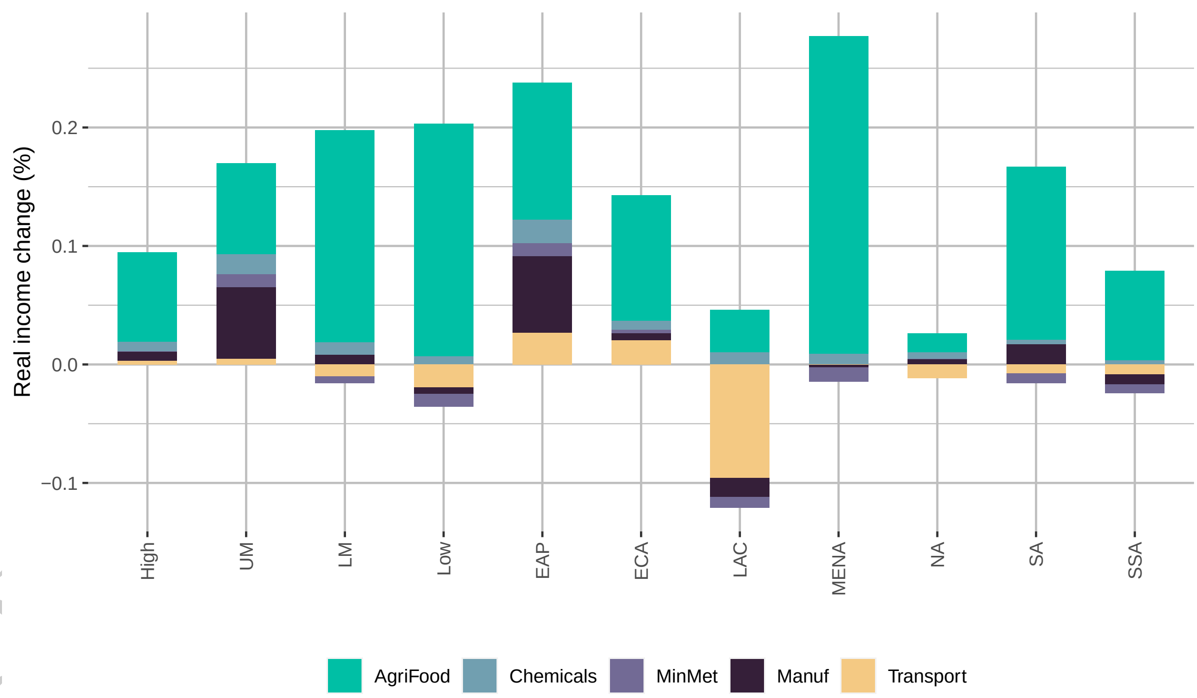
NTM shock	High	UM	LM	Low	EAP	ECA	LAC	MENA	NA	SA	SSA	Total
All												
$\tilde{t}^{s,\tau}, \tilde{t}^{s,\mathrm{imp}}, \tilde{t}^{s,\mathrm{exp}}$	0.09	0.17	0.18	0.17	0.24	0.14	-0.07	0.26	0.01	0.15	0.05	0.12
$\tilde{t}^{s,\tau}, \tilde{t}^{s,\mathrm{imp}}$	0.09	0.18	0.19	0.20	0.26	0.13	-0.11	0.23	0.02	0.11	-0.02	0.12
$\tilde{t}^{s,\tau}$	0.14	0.36	0.32	0.30	0.46	0.24	-0.06	0.43	-0.01	0.23	0.10	0.22
Structure												
$\tilde{t}^{s,\tau}, \tilde{t}^{s,\mathrm{imp}}, \tilde{t}^{s,\mathrm{exp}}$	0.10	0.13	0.20	0.23	0.20	0.13	0.00	0.27	0.03	0.15	0.08	0.12
$\tilde{t}^{s,\tau}$	0.17	0.26	0.36	0.40	0.38	0.22	0.02	0.43	0.05	0.23	0.14	0.21
Stringency												
$\tilde{t}^{s,\tau}, \tilde{t}^{s,\mathrm{imp}}$	-0.01	0.04	-0.01	-0.06	0.03	0.01	-0.07	-0.01	-0.01	0.00	-0.02	0.00
$\tilde{t}^{s,\tau}$	-0.03	0.10	-0.03	-0.09	0.08	0.02	-0.07	0.00	-0.06	0.00	-0.03	0.01
Combined												
$\tilde{t}^{s,\tau}, \tilde{t}^{s,\mathrm{imp}}$	-0.02	-0.01	-0.02	-0.04	-0.03	-0.01	-0.04	-0.04	-0.01	0.00	-0.02	-0.02
$\tilde{t}^{s,\tau}$	-0.03	-0.01	-0.04	-0.08	-0.03	-0.03	-0.05	-0.06	-0.02	0.00	-0.03	-0.03
Imputed (All)												
$\tilde{t}^{s,\tau}, \tilde{t}^{s,\mathrm{imp}}, \tilde{t}^{s,\mathrm{exp}}$	0.13	0.27	0.32	0.79	0.35	0.16	-0.03	0.53	0.03	0.21	0.44	0.18

Note: NTM shock: $(\tilde{t}^{s,\tau}, \tilde{t}^{s,\mathrm{imp}}, \tilde{t}^{s,\mathrm{exp}})$ 50% iceberg, 50% rents with harmonization rents equally split between importer and exporter, and stringency- and divergence-related rents accrue to importer, $(\tilde{t}^{s,\tau}, \tilde{t}^{s,\mathrm{imp}})$ 50% iceberg, 50% rents on importer side only, $(\tilde{t}^{s,\tau})$ 100% iceberg.

benefit from regulatory harmonization, upper-middle-income countries (particularly those in East Asia & Pacific) are the only ones for which technical measures' trade-promoting effect outweighs their trade cost effect – i.e. these countries experience positive effects of stricter regulation in machinery, metal products, chemicals, light manufacturing and textile products. This effect increases with a larger iceberg trade cost component in the shock. Positive income effects of regulatory changes depend on the inclusion of changes in bilateral regulatory differences because the single indicator model leads to a loss in real income of 0.02%. Moreover, results for a scenario with imputed regulatory changes suggest that positive income effects of regulatory changes are potentially larger.[32] Particularly for countries in Sub-Saharan Africa and Middle East & North Africa the real income effect may be twice to nine times larger.

The magnitude of income effects depends on the inclusion heterogeneous NTM effects as well as on the geographic coverage of trade cost changes. Webb et al. (2020) and Walmsley and Strutt (2021) investigate technical NTMs within an ASEAN context and find an economic wel-

Figure 4: Contribution of aggregate sectors to real income changes (in %)



Note: 3) Real income changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). We sum trade cost changes caused by changes in regulatory stringency and difference.

[32]In the fully imputed scenario we replace all regulatory changes with an estimated change, which is derived from neighboring and reference countries' regulatory changes, as well as notification activity to the WTO (see Appendix H).

fare gain ranging from 0.3 to 1.5% for six major ASEAN countries based on a 20% reduction of NTM-related trade costs.[33] These effects are larger compared a 0.02% income gain generated by 20% reduction in NTMs from their 2017 baseline value based on trade cost estimates from our single indicator model. Simulating only intra-ASEAN trade cost changes for 2012 to 2017 in the heterogeneous effect model results in 0.05% income gain.[34] Once trade cost changes vis-a-vis and between all other countries are taken into account regulatory developments in the five year period lead to real income changes of -0.06% and 0.44% for the six ASEAN countries based on the single indicator and heterogeneous effect model, respectively. Thus, our NTM estimates and model generate lower income effects for a similar NTM trade cost shock. These become larger once global changes and differentiated NTM effects are accounted for. On average, real income changes as a result of regulatory changes from 2012 to 2017 are smaller compared to macroeconomic results obtained from e.g. a global upgrade of all existing PTAs to deep PTAs (0.4% GDP growth, Fontagné et al., 2021), improvements of trade facilitation infrastructure in middle- and low-income countries (0.98% change in real consumption, Oberhofer et al., 2021), or effects of Brexit on the UK economy (1.3% change in equivalent variation as share in consumption, Dhingra et al., 2017). However, for individual countries income changes may be larger than these average effects, which illustrates the importance to monitor and evaluate regulatory developments.

The contribution of sector-level regulatory changes to income follow the pattern of sector contributions to global export changes presented in Figure 1. Figure 4 highlights these contributions to income changes by region and income group. The majority of total income gains can be attributed to regulatory changes in agri-food products, whereas for manufacturing sectors trade liberalizing effects of regulatory reform in chemicals, mineral and metal products, and manufacturing generate the largest increases in incomes across most regions and income levels. On the regional level, particularly in East Asia & Pacific regulatory changes in manufacturing sectors contribute similarly to income gains as agri-food sectors. Thus, regulatory developments that establish a more central role of East Asia & Pacific in the global trade network identified in Table 6 are driven by regulatory changes in multiple sectors. By contrast, the Americas experience an overall income loss, which is mainly explained by regulatory changes

[33] Both studies use a comparable general equilibrium model and use a gravity framework to estimate elasticities of technical measures. We transform their welfare results presented as USD in equivalent variation into a % of income in 2017. The six ASEAN countries are: Singapore, Thailand, Malaysia, Vietnam, Philippines, Indonesia.

[34] Details and results of the ASEAN-only simulations are available upon request.

affecting the automobile sector. For trade within NAFTA, we model a modest trade cost increase of 2-6 percentage points, which is caused by an increase in regulatory stringency.[35] This increase in combination with a relatively high trade elasticity and a large volume of affected trade flows explain the notable effects.

4 Conclusion

The results of our analysis show that regulatory harmonization during 2012 and 2017 shifted trade patterns towards a more central role of East Asia & Pacific, Europe & Central Asia, and South Asia in the global trade network. The shift in trade patters is driven by changes in trade across all sectors with the highest contribution of agri-food and chemical sectors. Overall, we find a global gain in real income of 0.12%. The magnitude of changes in real income increases with a higher share of trade cost changes represented as iceberg trade costs.

This paper conveys two important lessons for modeling NTMs that emphasize the relevance of accounting for pair-specific trade policy frictions and the third country effects of policy changes that determine these frictions. First, introducing bilateral regulatory differences that capture harmonization and divergence effects matters significantly for the final outcome of regulatory reform simulations. Trade cost changes derived from a single indicator gravity model do not sufficiently reflect the underlying trade cost structure of standard-like NTMs. This results in a global trade and real income effect that is 0.34 and 0.25 percentage points, respectively, lower compared to the heterogeneous effect model. Second, modeling isolated scenarios of NTM reform leads to biased inference because most NTM regulations change vis-a-vis all countries and not only a confined/limited set of countries – e.g. a three country convergence scenario needs to account for corresponding trade costs changes with the rest of the world. For example, the real income gain of six major ASEAN countries is nine times larger in a scenario that includes global regulatory changes versus one that only models intra-ASEAN trade cost changes.

Our results imply that the design of technical regulation significantly changes firms' trade costs vis-a-vis their import sources and export destinations. Thus, domestic policy reform and policy changes of main trade partners potentially lead to significant unintended economic

[35]Note that we do not find significant interaction effects of legally enforceable TBT provisions for the motor vehicle sector.

effects via the trade cost channel. This adds a layer of complexity to designing regulation that is mostly imposed with (non-)economic objectives other than trade. Our assessment of regulatory changes between 2012 and 2017 shows that imposing regulation that is similar to regulatory choices of main trade partners likely creates positive economic spillovers via a reduction in trade costs. Thus, long-term policy reform that considers the international trade cost environment is expected to generate significant welfare gains beyond its primary regulatory objective.

There are multiple interesting areas for future research related to this study. First, econometric estimates of specific types of technical and non-technical measures would allow for a more granular decomposition of trade and income effects by policy measure. Second, accounting for price and quantity effects of technical measures in the econometric estimation as well as implementation in the general equilibrium model would disentangle price-increasing and trade-promoting effects. These are currently combined in the trade volume effect that we convert to AVE trade cost changes. Third, econometric evidence on who bears the burden of NTM-related trade costs would provide further guidance with respect to how trade cost changes enter the general equilibrium model, as well as who would benefit most from regulatory reform. Lastly, ex-ante scenarios that describe different expectations of regulatory reform developments would inform about potential pathways of globalization.

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Appendices

- A: Non-tariff measures
- B: Countries and sectors
- C: Data
- D: Complete sectoral regressions
- E: Instrumentation by sector
- F: Summary of NTM elasticities
- G: Comparison of trade elasticities
- H: Outlier detection & imputation of regulatory change
- I: Trade cost changes
- J: Changes in trade
- K: Real income changes
- L: Imputation scenario

A Non-tariff measures

Table 8: Measures included in N^i

Measure group	Detailed measure description
SPS tolerance and use	A200: Tolerance limits for residues and restricted use of substances ; A210: Tolerance limits for residues of or contamination by certain (non-microbiological) substances; A220: Restricted use of certain substances in foods and feeds and their contact materials
SPS labels and marking	A300: Labelling, Marking and Packaging requirements; A310: Labelling requirements; A320: Marking requirements; A330: Packaging requirements
SPS Hygiene	A400: Hygienic requirements; A410: Microbiological criteria of the final product; A420: Hygienic practices during production; A490: Hygienic requirements n.e.s.
Post-prod. Treatment	A500: Treatment for elimination of plant and animal pests and disease-causing organisms in the final product or prohibition of treatment; A510: Cold/heat treatment; A520: Irradiation; A530: Fumigation; A590: Treatment for elimination of plant and animal pests and disease-causing organisms in the final product, n.e.s.
SPS Process control	A600: Other requirements on production or post-production processes; A610: Plant growth processes; A620: Animal raising or catching processes; A630: Food and feed processing; A640: Storage and transport conditions; A690: Other requirements on production or post-production processes, n.e.s
SPS conformity assessment	A800: Conformity assessment related to SPS; A810: Product registration and approval requirement ; A820: Testing requirement; A830: Certification requirement; A840: Inspection requirement; A850: Traceability requirements; A851: Origin of materials and parts; A852: Processing history; A853: Distribution and location of products after delivery; A859: Traceability requirements, n.e.s.; A890: Conformity assessment related to SPS n.e.s.
TBT tolerance and use	B200: Tolerance limits for residues and restricted use of substances; B210: Tolerance limits for residues of or contamination by certain substances; B220: Restricted use of certain substances
TBT labels and marking	B300: Labelling, Marking and Packaging requirements; B310: Labelling requirements; B320: Marking requirements; B330: Packaging requirements
TBT process control	B400: Production or Post-Production requirements; B410: TBT regulations on production processes; B420: TBT regulations on transport and storage; B490: Production or Post-Production requirements n.e.s.
TBT identity & performance	B600: Product identity requirement; B700: Product quality, safety or performance requirements
TBT conformity assessment	B800: Conformity assessment related to TBT; B810: Product registration/approval requirements; B820: Testing requirement; B830: Certification requirement; B840: Inspection requirement; B850: Traceability information requirements; B851: Origin of materials and parts; B852: Processing history; B853: Distribution and location of products after delivery; B859: Traceability requirements, n.e.s.; B890: Conformity assessment related to TBT n.e.s.

Table 9: Measures additionally included in N^{str}

Measure group	Detailed measure description
SPS	A100: Prohibitions/restrictions of imports for SPS reasons; A110: Prohibitions for sanitary and phytosanitary reasons ; A120: Geographical restrictions on eligibility; A130: Systems Approach; A140: Special Authorization requirement for SPS reasons; A150: Registration requirements for importers; A190: Prohibitions/restrictions of importsfor SPS reasons n.e.s.; A860: Quarantine requirement
TBT	B100: Import authorization/licensing related to technical barriers to trade; B140: Authorization requirement for TBT reasons; B150: Registration requirement for importers for TBT reasons; B190: Import authorization/licensing related to technical barriers to trade not elsewhere specified
Pre-shipment inspections	C000: Pre-shipment inspection and other formalities; C100: Pre-shipment inspection; C200: Direct consignment requirement; C300: Requirement to pass through specified port of customs; C400: Import monitoring and surveillance requirements and other automatic licensing measures; C900: Other formalities, n.e.s.

B Countries and sectors

Table 10: Country coverage

	High	UM	LM	Low
EAP	AUS; BRN; HKG; JPN; KOR; NZL; SGP	CHN; MYS; THA	IDN; KHM; LAO; PHL; VNM	
ECA	CHE; EU28	BLR; KAZ; RUS; TUR	KGZ	TJK
LAC	CHL; PAN; TTO; URY	ARG; BRA; COL; CRI; ECU; GTM; JAM; MEX; PER; PRY; VEN	BOL; HND; NIC; SLV	
MENA	ARE; BHR; ISR; KWT; OMN; QAT; SAU	DZA; JOR; LBN	MAR; PSE; TUN	
NA	CAN; USA			
SA		LKA	BGD; IND; PAK	AFG; NPL
SSA		BWA; MUS	CIV; CMR; GHA; NGA; SEN; ZWE	BEN; BFA; ETH; GIN; MLI; NER; TGO

Table 11: Country coverage – ISO codes and names

ISO	Name	ISO	Name	ISO	Name
AFG	Afghanistan	GIN	Guinea	NPL	Nepal
ARE	United Arab Emirates	GTM	Guatemala	NZL	New Zealand
ARG	Argentina	HKG	Hong Kong SAR China	OMN	Oman
AUS	Australia	HND	Honduras	PAK	Pakistan
BEN	Benin	IDN	Indonesia	PAN	Panama
BFA	Burkina Faso	IND	India	PER	Peru
BGD	Bangladesh	ISR	Israel	PHL	Philippines
BHR	Bahrain	JAM	Jamaica	PRY	Paraguay
BLR	Belarus	JOR	Jordan	PSE	Palestinian Territories
BOL	Bolivia	JPN	Japan	QAT	Qatar
BRA	Brazil	KAZ	Kazakhstan	RUS	Russia
BRN	Brunei	KGZ	Kyrgyzstan	SAU	Saudi Arabia
BWA	Botswana	KHM	Cambodia	SEN	Senegal
CAN	Canada	KOR	South Korea	SGP	Singapore
CHE	Switzerland	KWT	Kuwait	SLV	El Salvador
CHL	Chile	LAO	Laos	TGO	Togo
CHN	China	LBN	Lebanon	THA	Thailand
CIV	Cote d'Ivoire	LKA	Sri Lanka	TJK	Tajikistan
CMR	Cameroon	MAR	Morocco	TTO	Trinidad & Tobago
COL	Colombia	MEX	Mexico	TUN	Tunisia
CRI	Costa Rica	MLI	Mali	TUR	Turkey
DZA	Algeria	MUS	Mauritius	URY	Uruguay
ECU	Ecuador	MYS	Malaysia	USA	United States
ETH	Ethiopia	NER	Niger	VEN	Venezuela
EU28	European Union	NGA	Nigeria	VNM	Vietnam
GHA	Ghana	NIC	Nicaragua	ZWE	Zimbabwe

Table 12: Sector aggregation

Aggregation	Sector
Grains	pdr: Paddy rice; wht: Wheat; gro: Cereal grains nec
Veg & Fruits	v_f: Vegetables, fruit, nuts
Crops	osd: Oil seeds; c_b: Sugar cane, sugar beet; pfb: Plant-based fibers; ocr: Crops nec
Animal	ctl: Bovine cattle, sheep and goats, horses; oap: Animal products nec; rmk: Raw milk; wol: Wool, silk-worm cocoons; fsh: Fishing
Extr Nrg	coa: Coal; oil: Oil; gas: Gas; oxt: Other Extraction (formerly omn Minerals nec); frs: Forestry; p_c: Petroleum, coal products
Food Anm	cmt: Bovine meat products; omt: Meat products nec; mil: Dairy products
Food Plant	vol: Vegetable oils and fats; pcr: Processed rice; sgr: Sugar; ofd: Food products nec; b_t: Beverages and tobacco products
Tex	tex: Textiles; wap: Wearing apparel; lea: Leather products
Light Mfc	lum: Wood products; ppp: Paper products, publishing; omf: Manufactures nec
Chem	chm: Chemical products
Pharma	bph: Basic pharmaceutical products
Plastics	rpp: Rubber and plastic products
Mineral	nmm: Mineral products nec
Metal	i_s: Ferrous metals; nfm: Metals nec
Metal products	fmp: Metal products
Electr Comp	ele: Computer, electronic and optical products
Electr Eq	eeq: Electrical equipment
Machinery	ome: Machinery and equipment nec
Transport	otn: Transport equipment nec
Auto	mvh: Motor vehicles and parts
Services	ely: Electricity; gdt: Gas manufacture, distribution; wtr: Water; cns: Construction; trd: Trade; afs: Accommodation, Food and service activities; otp: Transport nec; wtp: Water transport; atp: Air transport; whs: Warehousing and support activities; cmn: Communication; ofi: Financial services nec; ins: Insurance (formerly isr); rsa: Real estate activities; obs: Business services nec; ros: Recreational and other services; osg: Public Administration and defense; edu: Education; hht: Human health and social work activities; dwe: Dwellings

C Data

We source data on technical regulations from UNCTAD (2017), which contains detailed product-level information about the number and types of technical measures. NTMTRAINS is based on full legislative reviews conducted at a given point in time and thus suitable to analyze regulatory differences, which contrasts notification-based data sources that contain information on changes in regulation but do not offer complete regulatory profiles.

Dependent on the year of data collection NTMTRAINS records the earliest year for which a specific type of measure is in force, which enables us to calculate changes in regulatory differences between 2012 and 2017. However, the number of measures of a certain type is constant for each vintage of data collection – e.g. if three conformity assessment requirements are imposed in 2017 the data only indicates the earliest year in which any of those three measures was introduced and omits information on potential joint introduction or phasing-in of additional measures.[36] For this reason we impute the difference of change of regulatory stringency (see Section 2.2 and Appendix H). If a legislative review is not available for our reference year 2017, we prefer information from the latest available collection year prior to 2017 over data collected after 2017. In either case, we use entry into force dates for specific measures types to limit the analysis to measure types in force in 2017.

In total, our analysis includes 76 types of technical measures of which 39 are likely imposed on domestic firms and defined sufficiently narrow to enter indicators reflecting regulatory differences.[37] Thus, for N_{od}^{dif} we exclude measures defined at high levels of the MAST classification or those coded as "not elsewhere specified/classified" because for such broadly defined measure groups we cannot establish whether regulatory profiles are (dis)similar and lead to corresponding changes in difference-based trade costs captured by N_{od}^{dif}. Furthermore, we source WTO notifications from Ghodsi et al. (2017) to construct indicators of change in regulatory stringency. Ghodsi et al. (2017) impute HS codes based on text matching techniques, which increases the product coverage compared to notification directly obtained from the WTO. Their data is available until 2016 such that changes from 2012 to 2016 are a reasonable proxy for changes from 2012 to 2017.

[36]The difference between unique number of specific measure types and total number of measures is particularly significant in agri-food sectors.

[37]Data in NTMTRAINS is coded according the the NTM classification developed by the Multi-Agency Support Team (MAST), which distinguishes between over 170 different types of technical and non-technical NTMs (UNCTAD, 2019).

Additionally, applied tariffs are the simple average of tariffs compiled at the 6-digit HS-level from ITC MacMap, the TRAINS database, and WTO. We give preference to preferential and MFN tariffs from MacMap because it is the main data provider to the GTAP database. We fill gaps in MacMap with TRAINS' preferential or applied MFN tariffs, as well as WTO bound rates if neither MacMap nor TRAINS contains any tariff information. Reporting gaps are filled with the latest available rates, assuming that for preferential rates the reporting gap is shorter than 5 years.

The variables in vector Z_{od} and instruments I_{od} include standard trade cost variables from CEPII (log of physical distance, contiguity, log of differences in latitude, common legal background, colonial past, time difference, common religion, common official language), a common language variable from Gurevich et al. (2021), PTA information from Hofmann et al. (2017), an indicator variable representing whether two countries used to be the same. Moreover, to control for bilateral differences in polity and governance we use the first three components of a principal component analysis of absolute bilateral difference in governance indicators from the World Bank (voice and accountability, political stability and absence of violence, government effectiveness, rule of law, control of corruption), and polity indicators from Freedom House (level of democracy, civil liberties, political rights), Polity IV (regime durability), political competition (Vanhanen, 2019) and political constraints (Henisz, 2017). Additionally, Z_{od} includes an international border interaction with the OECD trade facilitation indicator and a variable representing the combined economic mass of the country pair (log of combined GDP retrieved from the World Bank).

Lastly, we obtain international and domestic trade data for the gravity estimations from the GTAP 11 database (Aguiar et al., 2022), which is also the underlying database for the general equilibrium model. We model the trade and macroeconomic effects of changes in NTMs for 78 countries that are represented in the GTAP and NTMTRAINS database with one rest-of-world (ROW) region and the EU as one bloc.[38] On the sectoral level, GTAP's goods sectors are aggregated to 20 sectors (see Appendix B), for which we assume that trade cost determinants included in the gravity regressions are relatively homogeneous. In total, the analysis – i.e.

[38]NTMTRAINS data are collected for EU legislation. EU countries enter separately into the gravity equation to allow for a clear pairwise mapping of trade cost variables (e.g. colonial history, common language). For the general equilibrium assessment we aggregate EU countries to one bloc to avoid varying trade cost changes depending on which EU country is importer or exporter. Thus, countries' AVE trade cost changes with EU countries are aggregated based on their respective trade weights. Moreover, ROW countries do not enter the gravity estimations and are not affected by trade cost changes.

trade between non-ROW countries – covers 84% of world goods trade.

D Complete sectoral gravity regressions

Table 13: Sectoral gravity regressions I

	Grains	Veg & Fr	Crops	Animal	Extr Nrg	Fd Anm	Fd Plant	Tex	Lgt Mfc	Chem
Main equation										
Distance	-0.571 ***	-0.578 ***	-0.152	-0.499 ***	-0.406 ***	-0.338 ***	-0.349 ***	-0.215 *	-0.266 ***	-0.326 ***
	(0.217)	(0.156)	(0.146)	(0.163)	(0.119)	(0.125)	(0.069)	(0.128)	(0.093)	(0.072)
Contiguity	0.809 ***	0.505 *	0.450	0.058	0.168	0.740 ***	0.519 ***	0.614 ***	0.507 ***	0.198
	(0.312)	(0.275)	(0.292)	(0.199)	(0.242)	(0.203)	(0.158)	(0.220)	(0.195)	(0.133)
Latitude	0.101	0.191 ***	0.032	-0.158 ***	-0.042	-0.033	-0.001	-0.050	-0.093 **	-0.139 ***
	(0.094)	(0.054)	(0.056)	(0.047)	(0.049)	(0.041)	(0.026)	(0.042)	(0.037)	(0.029)
Comlang	0.177	0.272	0.524	0.982 ***	0.671 **	1.499 ***	1.303 ***	-0.052	1.103 ***	0.987 ***
	(0.434)	(0.340)	(0.333)	(0.379)	(0.268)	(0.302)	(0.163)	(0.208)	(0.252)	(0.139)
Mass	0.219 ***	0.025	0.228 ***	0.192 ***	0.328 ***	0.043	0.060 **	0.272 ***	0.237 ***	0.117 ***
	(0.082)	(0.062)	(0.079)	(0.060)	(0.077)	(0.054)	(0.031)	(0.063)	(0.044)	(0.038)
Pol1	-0.004	0.049 *	0.162 ***	0.122 ***	0.044 **	0.076 ***	0.021	0.057 **	0.072 ***	-0.038 **
	(0.043)	(0.026)	(0.029)	(0.024)	(0.022)	(0.027)	(0.014)	(0.023)	(0.020)	(0.016)
Pol2	0.041	-0.032	0.080 *	0.126 ***	0.027	0.056	0.059 ***	0.008	0.064 **	0.085 ***
	(0.057)	(0.038)	(0.048)	(0.045)	(0.042)	(0.046)	(0.020)	(0.035)	(0.032)	(0.021)
Pol3	-0.281 **	0.072	-0.014	-0.073	-0.029	0.032	-0.024	-0.065	-0.108 **	0.032
	(0.141)	(0.051)	(0.054)	(0.052)	(0.053)	(0.054)	(0.031)	(0.048)	(0.042)	(0.035)
Border	-16.319 ***	-13.293 ***	-18.656 ***	-19.144 ***	-16.103 ***	-14.508 ***	-10.040 ***	-13.003 ***	-14.243 ***	-11.106 ***
	(2.076)	(1.753)	(1.727)	(1.578)	(1.972)	(1.461)	(0.854)	(1.656)	(1.268)	(0.963)
Trade Facilitation	0.199 **	0.433 ***	0.411 ***	0.475 ***	0.177 ***	0.404 ***	0.257 ***	0.056	0.241 ***	0.282 ***
	(0.082)	(0.065)	(0.073)	(0.058)	(0.068)	(0.055)	(0.032)	(0.076)	(0.040)	(0.034)
EU	-1.363	-0.275	-1.445 *	1.449	-0.389	1.840 ***	-0.517 *	-0.225	-2.082 **	0.985
	(1.535)	(0.414)	(0.826)	(1.000)	(1.189)	(0.443)	(0.298)	(1.328)	(1.008)	(0.830)
PTA pre2012	0.675 *	0.845 ***	0.372	0.517 **	0.471 *	0.480 *	0.356 **	0.209	-0.400	0.179
	(0.395)	(0.247)	(0.238)	(0.239)	(0.258)	(0.263)	(0.139)	(0.302)	(0.263)	(0.159)
PTA Tech pre2012	1.259 *	0.792 **	0.375	0.616	0.707 *	0.987 **	-0.051	0.585 *	0.681 **	0.235
	(0.758)	(0.360)	(0.456)	(0.410)	(0.416)	(0.489)	(0.281)	(0.337)	(0.317)	(0.232)
PTA post2012	-0.817	-0.439	-1.219	-0.068	0.417	0.732	0.181	-0.147	-1.289 **	-0.088
	(1.322)	(0.569)	(0.757)	(0.796)	(0.649)	(0.638)	(0.387)	(0.384)	(0.645)	(0.350)
PTA Tech post2012	0.452	3.973 *	2.277	0.562	3.599 **	-0.128	-0.159	-3.172 ***	0.207	-0.354
	(3.434)	(2.216)	(1.548)	(2.139)	(1.722)	(1.751)	(0.761)	(0.938)	(1.202)	(0.747)
Tariff	-1.928	-2.599 ***	-4.422 ***	-6.833 **	-8.179 *	-3.890 ***	-1.951 **	-10.403 ***	-12.447 ***	-8.745 ***

	Grains	Veg & Fr	Crops	Animal	Extr Nrg	Fd Anm	Fd Plant	Tex	Lgt Mfc	Chem
	(1.401)	(0.856)	(1.613)	(2.761)	(4.450)	(0.888)	(0.856)	(1.426)	(2.010)	(2.332)
Dif	0.411 ***	0.155 **	0.612 ***	0.050	0.471	0.075	0.152 ***	-0.048	0.215	-0.141
	(0.131)	(0.067)	(0.188)	(0.141)	(0.468)	(0.080)	(0.046)	(0.223)	(0.358)	(0.177)
Dif*Msh	-0.023 ***	0.006	0.018	0.015	0.079 **	-0.003	-0.006	-0.009	-0.041 **	-0.006
	(0.009)	(0.006)	(0.014)	(0.010)	(0.034)	(0.006)	(0.004)	(0.009)	(0.020)	(0.012)
Dif*Xsh	0.020 **	-0.014 **	0.001	-0.008	-0.036	-0.002	0.002	-0.042 ***	-0.042 **	-0.010
	(0.009)	(0.006)	(0.020)	(0.010)	(0.034)	(0.007)	(0.005)	(0.009)	(0.017)	(0.010)
Dif*PTA Tech pre2012	-0.036	-0.079 ***	-0.141	0.081	0.458	0.084 **	0.006	-0.024	-0.547 **	0.154
	(0.068)	(0.024)	(0.103)	(0.085)	(0.315)	(0.042)	(0.023)	(0.109)	(0.246)	(0.100)
Dif*PTA Tech post2012	-0.061	-0.386 *	-0.111	1.319 **	-3.002	0.321	0.035	2.047 **	2.336	-0.244
	(0.530)	(0.200)	(0.548)	(0.673)	(4.184)	(0.215)	(0.059)	(0.876)	(2.094)	(0.570)
Border*NTM	-0.011	0.005	0.168 ***	0.057	0.046	0.025	0.009	0.623 ***	0.609 ***	0.121 *
	(0.024)	(0.026)	(0.047)	(0.046)	(0.275)	(0.020)	(0.018)	(0.154)	(0.232)	(0.068)
NTM*Msh	-0.007 **	0.001	0.022 ***	0.003	0.080 **	0.001	-0.000	0.003	0.015	0.015 *
	(0.003)	(0.003)	(0.006)	(0.004)	(0.033)	(0.003)	(0.002)	(0.011)	(0.022)	(0.008)
NTM*Xsh	0.011 ***	0.003	0.009	0.005	-0.042	0.002	0.003	0.074 ***	0.055	-0.002
	(0.004)	(0.003)	(0.007)	(0.006)	(0.048)	(0.003)	(0.003)	(0.018)	(0.034)	(0.013)
NTM*PTA Tech pre2012	0.034 *	-0.019 **	-0.002	-0.004	0.266	-0.001	0.011	-0.200 **	-0.356 ***	0.061 *
	(0.020)	(0.009)	(0.025)	(0.020)	(0.234)	(0.013)	(0.009)	(0.097)	(0.132)	(0.037)
NTM*PTA Tech post2012	0.031	-0.156 *	-0.070	0.034	-3.431	0.018	0.003	2.455 ***	1.142	0.017
	(0.176)	(0.082)	(0.106)	(0.120)	(2.607)	(0.046)	(0.025)	(0.736)	(0.850)	(0.194)
Comlegal (post)	0.154	-0.015	0.305 **	-0.210	0.082	-0.042	-0.054	0.048	-0.034	-0.055
	(0.199)	(0.114)	(0.137)	(0.134)	(0.183)	(0.102)	(0.066)	(0.083)	(0.084)	(0.063)
Comlegal (pre)	-0.097		-0.429 ***	0.555 ***	0.018					
	(0.215)		(0.155)	(0.146)	(0.202)					
Comcol	2.068 ***	0.373	0.290	0.390	0.567 **	0.344		-0.003	1.485 ***	0.216
	(0.443)	(0.375)	(0.398)	(0.493)	(0.265)	(0.339)		(0.292)	(0.341)	(0.163)
Col45	-0.415						0.453 **	0.638 ***		0.689 ***
	(0.523)						(0.201)	(0.188)		(0.261)
Col dep ever	1.362 ***	0.588 **		0.383 *	0.459 **		0.363 **		0.074	-0.255
	(0.499)	(0.255)		(0.201)	(0.192)		(0.151)		(0.164)	(0.185)
Comrelig					0.015 ***	-0.001		0.002		0.004
					(0.004)	(0.003)		(0.003)		(0.002)
Comlang off			-0.578 ***	-0.648 ***		-0.099	-0.201 *		-0.122	
			(0.221)	(0.221)		(0.176)	(0.110)		(0.172)	
Same country		-1.479				0.568	0.463	0.587	0.148	

	Grains	Veg & Fr	Crops	Animal	Extr Nrg	Fd Anm	Fd Plant	Tex	Lgt Mfc	Chem
		(1.057)				(0.459)	(0.370)	(0.558)	(0.585)	
Same col ever		0.443 *	0.439				-0.007			
		(0.227)	(0.274)				(0.113)			
Time diff	-0.100 **		0.065 ***		-0.107 ***	0.059 ***		-0.004	0.016	-0.045 **
	(0.044)		(0.025)		(0.023)	(0.019)		(0.027)	(0.023)	(0.019)
CF Dif	-0.463 ***	-0.198 ***	-0.572 ***	0.069	-0.107	-0.126 **	-0.204 ***	-0.254	-0.803 **	0.040
	(0.120)	(0.050)	(0.150)	(0.134)	(0.516)	(0.052)	(0.041)	(0.226)	(0.312)	(0.163)
CF PTA	-0.198	0.071	-0.022	-0.166	0.208	-0.473 ***	0.043	-0.283 *	0.169	0.030
	(0.210)	(0.142)	(0.158)	(0.148)	(0.135)	(0.148)	(0.088)	(0.148)	(0.118)	(0.087)
CF PTA Tech	-1.147 ***	-0.498 ***	-0.199	-0.379 **	-0.604 ***	0.108	-0.066	-0.016	-0.155	-0.155
	(0.372)	(0.163)	(0.193)	(0.173)	(0.185)	(0.188)	(0.113)	(0.140)	(0.151)	(0.102)
2nd stage FE decomposition										
NTM	0.036	0.004	0.024	-0.006	0.315	-0.058	-0.004	-0.018	-0.014	0.061 ***
	(0.111)	(0.012)	(0.030)	(0.060)	(0.312)	(0.058)	(0.004)	(0.053)	(0.054)	(0.022)
MR	-0.835	-0.843 ***	-0.809 **	-0.692 *	-0.379	-0.523	-0.825 ***	-0.709 ***	-0.985 ***	-0.891 ***
	(0.663)	(0.129)	(0.321)	(0.381)	(0.516)	(0.477)	(0.080)	(0.169)	(0.187)	(0.123)
Demand	0.862 *	0.963 ***	0.601 **	0.666 ***	0.767 ***	0.769 **	0.887 ***	0.773 ***	0.954 ***	0.726 ***
	(0.514)	(0.184)	(0.244)	(0.225)	(0.146)	(0.338)	(0.072)	(0.138)	(0.113)	(0.108)
GDPpc	0.244	0.035	-0.044	0.157	-0.436	-0.294	-0.222 ***	-0.228 *	-0.154	-0.270 ***
	(1.530)	(0.167)	(0.233)	(0.381)	(0.393)	(0.307)	(0.070)	(0.119)	(0.140)	(0.087)
Pol1	0.322	-0.044	-0.079	0.009	0.063	0.040	0.093 ***	0.064	0.087	0.113 ***
	(0.487)	(0.072)	(0.097)	(0.153)	(0.112)	(0.279)	(0.022)	(0.039)	(0.057)	(0.034)
Pol2	-0.141	0.042	-0.008	0.180	0.087	0.227	0.107 ***	0.079 ***	0.105 ***	0.089 ***
	(0.507)	(0.072)	(0.119)	(0.172)	(0.211)	(0.262)	(0.027)	(0.026)	(0.033)	(0.030)
Pol3	0.523	-0.143 *	0.222 **	0.051	0.033	0.118	-0.002	-0.034	-0.046	0.076
	(0.953)	(0.080)	(0.105)	(0.135)	(0.156)	(0.309)	(0.035)	(0.040)	(0.042)	(0.049)
Pol4	-0.101	0.024	-0.242 **	-0.203	-0.090	-0.231	-0.046	0.034	-0.062	-0.093 *
	(0.546)	(0.091)	(0.114)	(0.138)	(0.220)	(0.248)	(0.041)	(0.072)	(0.045)	(0.050)

Table 14: Sectoral gravity regressions II

	Pharma	Plastics	Mineral	Metal	Metal pr	El Comp	El Eq	Machine	Transport	Auto
Main equation										
Distance	-0.084	-0.510 ***	-0.683 ***	-0.254 ***	-0.434 ***	-0.341 ***	-0.457 ***	-0.404 ***	-0.198	-0.485 ***
	(0.094)	(0.083)	(0.129)	(0.074)	(0.088)	(0.108)	(0.100)	(0.073)	(0.148)	(0.080)
Contiguity	0.217	0.477 ***	0.355 **	-0.080	0.922 ***	0.522 ***	0.564 **	0.452 **	0.301	0.819 ***
	(0.186)	(0.171)	(0.177)	(0.164)	(0.186)	(0.199)	(0.257)	(0.177)	(0.259)	(0.235)
Latitude	-0.195 ***	-0.127 ***	-0.205 ***		-0.010	0.138 ***	0.026	0.027	-0.077	0.021
	(0.043)	(0.030)	(0.033)		(0.030)	(0.043)	(0.037)	(0.032)	(0.048)	(0.040)
Comlang	0.384	0.806 ***	0.974 ***	3.071 ***	0.611 ***	0.475 *	1.056 ***	0.818 ***	0.787 ***	0.743 ***
	(0.290)	(0.167)	(0.230)	(0.477)	(0.213)	(0.271)	(0.232)	(0.178)	(0.273)	(0.254)
Mass	0.198 ***	0.209 ***	0.266 ***	0.012	0.271 ***	0.289 ***	0.161 ***	0.279 ***	0.050	0.300 ***
	(0.066)	(0.047)	(0.047)	(0.056)	(0.038)	(0.060)	(0.047)	(0.035)	(0.086)	(0.070)
Pol1	-0.118 ***	0.065 ***	0.015	0.034	0.014	0.099 ***	0.074 ***	0.021	-0.074 ***	-0.007
	(0.027)	(0.021)	(0.021)	(0.023)	(0.020)	(0.028)	(0.021)	(0.017)	(0.028)	(0.024)
Pol2	0.057	0.054 **	0.038	0.064 *	0.015	0.104 *	-0.001	0.049 **	0.154 ***	0.049
	(0.040)	(0.023)	(0.028)	(0.036)	(0.028)	(0.056)	(0.028)	(0.023)	(0.040)	(0.031)
Pol3	0.083 *	0.018	-0.005	0.035	-0.108 *	-0.120 *	-0.035	-0.030	0.032	0.040
	(0.046)	(0.051)	(0.056)	(0.042)	(0.057)	(0.063)	(0.048)	(0.040)	(0.065)	(0.043)
Border	-17.864 ***	-12.041 ***	-14.531 ***	-7.847 ***	-16.195 ***	-14.153 ***	-11.754 ***	-16.677 ***	-12.078 ***	-15.115 ***
	(1.682)	(1.272)	(1.352)	(1.590)	(1.321)	(1.779)	(1.342)	(1.086)	(2.472)	(1.485)
Trade Facilitation	0.544 ***	0.147 ***	0.187 ***	0.369 ***	0.241 ***	0.150 ***	0.254 ***	0.311 ***	0.366 ***	0.202 ***
	(0.049)	(0.035)	(0.050)	(0.041)	(0.042)	(0.053)	(0.043)	(0.040)	(0.066)	(0.063)
EU	1.282	1.407	2.156	3.319	-11.145 ***	-3.440 **	0.535	-1.837	-2.522	-0.705
	(0.858)	(0.987)	(1.469)	(2.208)	(2.029)	(1.689)	(1.103)	(1.119)	(1.558)	(0.570)
PTA pre2012	0.117	0.609 ***	0.230	0.170	0.317	1.482 ***	1.160 ***	1.047 ***	1.152 ***	1.035 ***
	(0.239)	(0.211)	(0.239)	(0.269)	(0.244)	(0.264)	(0.220)	(0.189)	(0.331)	(0.223)
PTA Tech pre2012	0.423	0.490 **	0.602 **	0.633 **	1.035 ***	0.510 *	0.600	0.325	-0.096	0.222
	(0.364)	(0.242)	(0.249)	(0.301)	(0.299)	(0.306)	(0.372)	(0.303)	(0.343)	(0.327)
PTA post2012	0.052	-0.484	-0.645	-0.298	-0.365	1.148 **	0.029	0.007	-0.340	-0.623
	(0.900)	(0.516)	(0.483)	(0.530)	(0.381)	(0.542)	(0.525)	(0.409)	(0.709)	(0.653)
PTA Tech post2012	-1.158	0.496	0.350	-0.436	-0.251	-1.164	0.083	-0.339	-0.790	0.857
	(1.656)	(0.664)	(0.647)	(0.997)	(0.664)	(2.037)	(1.190)	(0.656)	(2.430)	(2.284)
Tariff	-8.905 **	-6.738 ***	-9.340 ***	-10.528 ***	-8.434 ***	-9.596 ***	-8.139 ***	-7.607 ***	-5.808 *	-9.289 ***
	(3.884)	(1.800)	(2.246)	(3.656)	(1.830)	(2.668)	(2.447)	(2.365)	(3.087)	(1.705)
Dif	-0.256	-0.202	-0.534	-0.714	2.794 ***	0.313	-0.021	0.308 **	1.011	0.569 *

	Pharma	Plastics	Mineral	Metal	Metal pr	El Comp	El Eq	Machine	Transport	Auto
	(0.200)	(0.212)	(0.410)	(0.666)	(0.532)	(0.278)	(0.184)	(0.153)	(0.657)	(0.302)
Dif*Msh	-0.051 ***	-0.033 ***	-0.022	-0.025	-0.027	-0.063 ***	-0.024 *	-0.008	-0.076 **	-0.116 ***
	(0.015)	(0.012)	(0.020)	(0.023)	(0.018)	(0.018)	(0.013)	(0.008)	(0.030)	(0.025)
Dif*Xsh	-0.002	-0.017	-0.010	-0.018	-0.020	-0.049 ***	-0.019 **	-0.012	0.017	0.002
	(0.018)	(0.014)	(0.019)	(0.021)	(0.019)	(0.012)	(0.010)	(0.009)	(0.039)	(0.033)
Dif*PTA Tech pre2012	-0.159	0.009	-0.003	0.664	0.043	-0.366 *	-0.259 ***	-0.056	-0.326	-0.214
	(0.164)	(0.178)	(0.504)	(0.511)	(0.368)	(0.188)	(0.081)	(0.081)	(0.367)	(0.167)
Dif*PTA Tech post2012	0.506	0.782	-1.469	0.292	5.060	-0.032	-0.255	0.365	3.083	0.087
	(1.019)	(0.858)	(4.045)	(2.746)	(5.231)	(2.048)	(0.537)	(0.330)	(4.746)	(0.964)
Border*NTM	-0.166 **	0.060	-0.261	0.046	0.889 ***	0.271 ***	-0.005	0.033	1.514 ***	-0.105
	(0.071)	(0.106)	(0.333)	(0.248)	(0.249)	(0.053)	(0.056)	(0.048)	(0.367)	(0.105)
NTM*Msh	0.008	-0.020 **	-0.020	0.034 *	-0.046 ***	0.008	-0.006	-0.009 ***	-0.022	-0.003
	(0.008)	(0.010)	(0.018)	(0.018)	(0.016)	(0.006)	(0.005)	(0.003)	(0.027)	(0.011)
NTM*Xsh	-0.025 **	0.027 *	-0.005	0.123 ***	0.004	0.034 ***	0.013	0.008	0.241 ***	-0.031
	(0.010)	(0.015)	(0.034)	(0.029)	(0.023)	(0.010)	(0.008)	(0.006)	(0.064)	(0.023)
NTM*PTA Tech pre2012	-0.043	0.005	-0.046	0.313	-0.020	-0.200 ***	-0.115 ***	-0.039	-0.184	-0.016
	(0.028)	(0.087)	(0.363)	(0.261)	(0.200)	(0.057)	(0.028)	(0.032)	(0.227)	(0.060)
NTM*PTA Tech post2012	0.166	0.541	-0.663	1.078	3.367	0.184	-0.023	0.366 *	2.118	0.039
	(0.223)	(0.524)	(2.531)	(1.590)	(3.093)	(0.711)	(0.377)	(0.205)	(2.579)	(0.233)
Comlegal (post)	0.113	0.072	0.088		0.631 ***	-0.033	0.444 ***	0.499 ***		0.356 ***
	(0.110)	(0.073)	(0.082)		(0.115)	(0.096)	(0.133)	(0.106)		(0.082)
Comlegal (pre)				-0.169 *	-0.632 ***		-0.274 **	-0.495 ***	-0.217 *	
				(0.089)	(0.120)		(0.139)	(0.112)	(0.124)	
Comcol	-0.859 **	-0.249		1.240 ***			-0.320		0.520	-0.485
	(0.351)	(0.217)		(0.261)			(0.250)		(0.342)	(0.402)
Col45	0.238	0.711 ***	0.802 ***	1.242 ***	0.279	-0.284		0.397	0.690 **	
	(0.304)	(0.240)	(0.288)	(0.277)	(0.206)	(0.422)		(0.275)	(0.273)	
Col dep ever			-0.227 *	-0.431 *	0.459 ***	0.413 **				-0.489 **
			(0.134)	(0.223)	(0.154)	(0.201)				(0.200)
Comrelig				0.009 **	0.005 *	0.003	0.007 **		0.007 *	0.013 ***
				(0.004)	(0.003)	(0.003)	(0.003)		(0.004)	(0.004)
Comlang off	0.054	-0.341 **	-0.383 *	-0.767 ***	-0.409 **	-0.157	-0.575 ***	-0.405 **		-0.648 ***
	(0.229)	(0.147)	(0.204)	(0.227)	(0.184)	(0.173)	(0.197)	(0.159)		(0.181)
Same country	1.756 ***	1.057 ***	0.680				1.038 ***	0.835 **		
	(0.567)	(0.363)	(0.578)				(0.370)	(0.375)		
Same col ever				-1.055 ***					-0.150	-0.108

	Pharma	Plastics	Mineral	Metal	Metal pr	El Comp	El Eq	Machine	Transport	Auto
				(0.223)					(0.263)	(0.241)
Time diff	-0.050 **	0.035 *	0.038	-0.052 ***		0.090 ***	0.051 ***	0.037 **	0.053 **	
	(0.022)	(0.018)	(0.028)	(0.017)		(0.028)	(0.020)	(0.015)	(0.025)	
CF Dif	0.001	0.119	0.340	0.961	-2.873 ***	-0.891 ***	-0.085	-0.308 **	-1.114 **	-0.849 ***
	(0.188)	(0.231)	(0.461)	(0.609)	(0.482)	(0.228)	(0.145)	(0.128)	(0.533)	(0.206)
CF PTA	-0.195	-0.118	0.050	-0.058	-0.146	-0.831 ***	-0.561 ***	-0.395 ***	-0.202	-0.374 **
	(0.159)	(0.100)	(0.118)	(0.161)	(0.127)	(0.166)	(0.132)	(0.113)	(0.199)	(0.150)
CF PTA Tech	0.083	-0.223 *	-0.450 ***	-0.240	-0.354 ***	-0.072	-0.025	-0.145	-0.092	0.045
	(0.204)	(0.114)	(0.123)	(0.193)	(0.126)	(0.139)	(0.153)	(0.131)	(0.183)	(0.205)
2nd stage FE decomposition										
NTM	0.087	-0.125 **	-0.106	0.175	0.009	0.084	-0.016	-0.022	-0.048	-0.532 *
	(0.092)	(0.060)	(0.130)	(0.150)	(0.147)	(0.142)	(0.017)	(0.020)	(1.119)	(0.300)
MR	-0.836 *	-0.483 ***	-0.929 ***	-0.485	-1.320 ***	-0.889	-0.793 ***	-1.052 ***	-0.829 ***	-7.237 ***
	(0.452)	(0.161)	(0.176)	(0.394)	(0.142)	(0.569)	(0.145)	(0.102)	(0.307)	(1.907)
Demand	0.709 *	0.697 ***	0.481 *	0.602 **	1.138 ***	0.671 **	0.863 ***	0.865 ***	0.801	2.536 ***
	(0.427)	(0.115)	(0.246)	(0.268)	(0.155)	(0.275)	(0.110)	(0.094)	(0.963)	(0.865)
GDPpc	-0.343	-0.290 **	-0.877 ***	-0.049	-0.198	-0.104	-0.361 *	-0.194	-0.146	0.644
	(0.530)	(0.126)	(0.285)	(0.343)	(0.296)	(0.205)	(0.185)	(0.122)	(1.111)	(2.188)
Pol1	0.094	0.071	0.306 ***	-0.070	0.049	0.116	0.081	0.099 *	0.122	0.385
	(0.554)	(0.050)	(0.099)	(0.082)	(0.094)	(0.251)	(0.067)	(0.055)	(0.537)	(0.847)
Pol2	0.189	0.048 **	0.292 ***	0.046	0.068	0.057	-0.025	-0.028	-0.215	0.458
	(0.353)	(0.020)	(0.112)	(0.074)	(0.083)	(0.266)	(0.046)	(0.034)	(0.358)	(0.437)
Pol3	-0.082	-0.001	0.214	0.033	-0.071	0.009	-0.033	-0.076	0.350	0.094
	(0.491)	(0.051)	(0.146)	(0.060)	(0.117)	(0.094)	(0.049)	(0.052)	(0.541)	(0.495)
Pol4	0.123	0.197 *	-0.093	-0.040	0.001	0.070	-0.182 **	0.025	0.278	1.661
	(0.275)	(0.102)	(0.150)	(0.080)	(0.129)	(0.115)	(0.082)	(0.059)	(0.486)	(1.049)

E Instrumentation by sector

Table 15: Instrumentation by sector

	Grains	Veg & Fruits	Crops	Animal	Extr Nrg	Food Anm	Food Plant	Tex	Light Mfc	Chem	Pharma	Plastics	Mineral	Metal	Metal products	Electr Comp	Electr Eq	Machinery	Transport	Auto
Latitude diff														•						
ComLegal (post)														•					•	
ComLegal (pre)		•				•	•	•	•	•	•	•	•			•				•
Comcol							•						•		•	•		•		
Col45		•	•	•	•	•			•								•			•
ColDep ever			•			•		•			•	•					•	•	•	•
Same ctry	•		•	•	•					•				•	•	•			•	•
SameCol ever	•			•	•	•		•	•	•	•	•	•		•	•	•	•		
Time diff		•		•			•								•					•
Comrelig	•	•	•	•			•		•		•	•	•					•		
Comlang off	•	•			•			•		•									•	
P-values Chisq test of joint significance																				
Excl. restriction	0.361	0.734	0.197	0.253	0.834	0.379	0.345	0.246	0.655	0.279	0.123	0.880	0.816	0.890	0.530	0.535	0.550	0.440	0.956	0.493
Relevance Dif	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Relevance PTA^T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.000	0.000
Relevance PTA	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.106	0.000	0.000	0.000

Note: Standard errors for test of joint significance based on bootstrapped standard errors, 200 replications.

F Summary of NTM elasticities

Table 16: Summary of gravity estimations

	Heterogeneous (HET) NTM effect						*Single ind. (SI)*		
	(1) Dif Q2	(2) Dif IRQ	(3) Str Q2	(4) Str IRQ	(5) Dif PTA Q2	(6) Str PTA Q2	(7) Str Q2	(8) Str IRQ	(9) $\hat{\sigma}$
Grains	0.45	0.15	–	–	–	–	–	–	2.68
Veg & Fruits	0.22	0.05	–	–	0.14	-0.04	–	–	2.56
Crops	0.47	0.05	-0.09	0.05	–	–	-0.09	0.04	3.49
Animal	–	–	–	–	–	–	–	–	7.75
Extr Nrg	–	–	–	–	–	–	–	–	8.06
Food Anm	0.11	0.01	–	–	–	–	-0.05	0.00	3.78
Food Plant	0.18	0.01	-0.02	0.01	–	–	-0.02	0.00	1.94
Tex	0.39	0.03	0.24	0.12	0.39	-0.30	-0.01	0.27	11.09
Light Mfc	0.76	0.13	0.23	0.07	–	-0.33	-0.20	0.11	12.04
Chem	–	–	0.11	0.03	–	–	0.12	0.04	8.78
Pharma	0.35	0.00	–	–	–	–	-0.11	0.04	7.69
Plastics	–	–	-0.20	0.03	–	–	-0.14	0.04	6.14
Mineral	–	–	–	–	–	–	–	–	8.84
Metal	–	–	-0.81	0.31	–	–	-0.57	0.27	10.09
Metal products	3.13	0.09	1.20	0.14	–	–	0.19	0.09	7.38
Electr Comp	1.09	0.28	–	–	0.76	–	-0.15	0.09	10.23
Electr Eq	0.30	0.07	-0.07	0.03	–	-0.17	-0.08	0.02	6.46
Machinery	0.45	0.04	0.06	0.02	–	–	-0.06	0.03	7.00
Transport	1.43	0.28	–	–	–	–	-0.62	0.38	5.39
Auto	1.45	0.52	-0.50	0.01	–	–	0.20	0.07	9.39

Note: 1) Total NTM-effect of β^i of Equation (3). Significance is evaluated for 100 midpoints of export-import-share bin combinations and based on bootstrapped standard errors, 200 replications. 2) Dif and Str refer to bilateral regulatory differences and regulatory stringency in the heterogeneous (HET) effect and single indicator (SI) model. 3) Q2/IQR refer to median and inter-quartile range. 4) Dif PTA and Str PTA are the median elasticities of bilateral regulatory differences and regulatory stringency within PTAs (pre 2012) for those sectors with significant PTA interaction effects.

G Comparison of trade elasticities

The estimated trade elasticities $\hat{\sigma}$ are comparable to estimates of Fontagné et al. (2022), who use ITC-based tariff data and pool product-level trade to estimate sectoral and total/overall trade elasticities, and elasticities provided by the GTAP database.

Table 17: Comparison of trade elasticities

	σ	ESUBM	FGO
Grains	2.68	5.99	3.22
Veg & Fruits	2.56	3.70	7.83
Crops	3.49	5.53	4.82
Animal	7.75	3.53	3.99
Extr Nrg	8.06	10.19	6.01
Food Anm	3.78	7.99	7.68
Food Plant	1.94	4.04	4.10
Tex	11.09	7.59	8.43
Light Mfc	12.04	6.90	2.86
Chem	8.78	6.60	8.28
Pharma	7.69	6.60	3.64
Plastics	6.14	6.60	6.46
Mineral	8.84	5.80	7.63
Metal	10.09	7.42	10.09
Metal products	7.38	7.50	7.04
Electr Comp	10.23	8.80	3.76
Electr Eq	6.46	8.80	6.04
Machinery	7	8.10	4.02
Transport	5.39	8.60	3.84
Auto	9.39	5.60	2.75

Note: 1) Aggregation of Fontagné et al. (2022, FGO) elasticities weighted by number of 6-digit tariff lines in original GTAP sector. 2) ESUBM refers to the substitution elasticities in the GTAP database.

H Outlier detection & imputation of regulatory change

The analysis uses NTM data from NTMTRAINS, which is the only global NTM data source sufficiently detailed to calculate bilateral regulatory differences based on specific measure types. NTMTRAINS records the earliest entry into force date for measure types in force at the time of data collection. For example, if there are two labeling requirements in force in 2017 NTMTRAINS provides information about when the older of the two entered into force. Thus, the data do not track regulatory stringency, defined as the average number of measures per product, over time unless regulatory data for a country were collected over multiple years. Moreover, it is uncertain whether measure types entering into force are new or a replacement of existing regulation. If a new measure is a replacement bilateral regulatory differences remain unchanged, whereas the introduction of a new measure type results in a harmonization or divergence event.

Table 18 summarizes the share of new measure types entering into force between 2012 and 2017 by country. A relatively high share of new measure types implies that a significant part of regulation in force in 2017 enter within the previous five years. For example, in the extreme case of Korea NTMTRAINS data suggest that all of Korea's technical regulation enter into force between 2012 and 2017. By extension, this implies that all bilateral harmonization and

Table 18: Share of new measures in 2017 since 2012

KOR	1.00	PAK	0.28	ARE	0.08	KHM	0.00
CRI	0.99	USA	0.25	URY	0.08	TUN	0.00
HND	0.98	BGD	0.25	BOL	0.08	PSE	0.00
SLV	0.98	VNM	0.24	MYS	0.06	AFG	0.00
GTM	0.97	COL	0.22	BWA	0.06	BFA	0.00
VEN	0.97	PER	0.22	OMN	0.06	CIV	0.00
KGZ	0.90	BEN	0.21	BRA	0.05	CMR	0.00
PAN	0.89	CHL	0.21	GHA	0.05	DZA	0.00
JPN	0.89	ARG	0.21	QAT	0.04	GIN	0.00
JOR	0.81	MEX	0.20	THA	0.03	HKG	0.00
TJK	0.67	SAU	0.18	LBN	0.03	NER	0.00
BLR	0.63	BHR	0.18	IND	0.03	NPL	0.00
RUS	0.55	MAR	0.16	BRN	0.02	SEN	0.00
KAZ	0.52	PHL	0.16	KWT	0.01	TGO	0.00
IDN	0.44	CHE	0.16	ISR	0.01	TTO	0.00
ECU	0.41	NIC	0.15	MUS	0.01	TUR	0.00
CHN	0.40	AUS	0.12	PRY	0.01	NZL	-0.17
ETH	0.37	EU28	0.11	CAN	0.01		
NGA	0.36	LKA	0.10	SGP	0.00		
ZWE	0.30	LAO	0.09	JAM	0.00		

Note: Bold countries are identified as outliers using $Q3+1.5*IQR$ as a threshold value.

divergence with Korea as a partner takes place between 2012 and 2017. This is an unrealistic representation of actual regulatory activity and demonstrates the need to search regulatory changes N_{Δ}^{i} for outliers. In addition, for 18 countries we cannot observe any regulatory activity, which may under-represent regulatory changes that took place. To investigate the effect of regulatory activity that we potentially ignore, Appendix L compares a scenario with fully imputed regulatory change vs. the main scenario presented in the text. Overall, in the absence of periodic updates of NTMTRAINS further research regarding the construction of indicators of regulatory change is necessary.

These properties of the NTM data motivate us to construct a benchmark regulatory change $N_{\Delta B}^{i}$, with $i \in \{\text{str}, \text{dif}\}$, to identify outlier N_{Δ}^{dif}, as well as to calculate, i.e. impute, changes in regulatory stringency N_{Δ}^{str}. The benchmark regulatory change $N_{\Delta B}^{i}$ is calculated as the weighted sum of changes in underlying determinants of N^{i} with weights given by coefficients of a corresponding OLS regression with N^{i} as dependent variable. As determinant for N^{i} we use the average NTM profile of the five closest neighboring countries in terms of geographic distance ($N^{i,D}$, i.e. D for distance) and the NTM profile of a group of reference countries identified by k-means clustering on polity, governance, and trade facilitation indicators, GDP per capita, and countries' latitude ($N^{i,R}$, i.e. R for reference) – see Ghodsi (2019) and Kee and Nicita (2022) for using neighboring countries' NTM profiles as instruments in gravity regressions and Guimbard et al. (2012) who use reference countries to construct trade-based weights to address bias in tariff aggregation. Thus, we assume that NTMs are a function of neighboring countries' trade policy, institutions, and economic development. Furthermore, we utilize the average number of SPS and TBT measures notified to the WTO ($N^{\text{str},WTO}$) as an additional source of regulatory activity.

The process of imputation for regulatory stringency and the two components of bilateral regulatory differences (harmonization and divergence events) follows three steps: regress N^{i} of 2017 on determinants of NTMs, predict benchmark regulatory change $N_{\Delta B}^{i}$ based on regression coefficients and changes in determinants from 2017 to 2012, use $N_{\Delta B}^{i}$ to identify outlier regulatory change.

H.1 Imputation of regulatory stringency

We impute changes in regulatory stringency because NTMTRAINS does not record changes in the number of measures imposed on a given product over time. For this, we pool across all sectors k and estimate the following model via OLS:

$$N_{dk}^{\text{str}} = \sum_p \beta^p N_{dk}^p + \delta_d + \varepsilon_{dk} \tag{H.1}$$
$$\text{with} \quad p \in \left\{N_{dk}^{\text{str},ND}, N_{dk}^{\text{str},NR}, N_{dk}^{\text{str},WTO}\right\}$$

N_{dk}^{str} is the average number of technical measures imposed by country d in 2017, and δ_d represents a country dummy capturing country-specific effects across all sectors. The change in regulatory stringency is defined by:[39]

$$N_{\Delta,dk}^{\text{str}} = \sum_p \hat{\beta}^p N_{\Delta,dk}^p$$

with $N_{\Delta,dk}^p$ representing changes in neighboring and reference countries' regulatory stringency from 2017 to 2012, as well as number of WTO notifications from 2016 to 2012.[40]

H.2 Regulatory differences

Our measure of bilateral regulatory differences is based on type similarity and constructed as the difference of harmonization and divergence events. Thus, it depends on the number of unique measure types imposed by a given country. The construction of changes in bilateral regulatory differences accounts for this and is conducted in four steps.

1. **Changes in the unique number of measures**

   We follow the same steps as for regulatory stringency and estimate regression equation (H.1) with the unique number of measure types imposed by country d (N_{dk}^{unq}) as dependent variable and explanatory variables $p \in \left\{N_{dk}^{\text{unq},ND}, N_{dk}^{\text{unq},NR}, N_{dk}^{\text{str},WTO}\right\}$. The inclusion of WTO notifications depends on WTO membership of country d.

[39] For countries not members of the WTO we estimate a model without WTO notification to retrieve weights $\hat{\beta}$.

[40] We use WTO notification data from Ghodsi et al. (2017), which include notifications until 2016. We prefer the significantly enhanced information on products affected by a notification in Ghodsi et al. (2017) over original WTO notification data available until 2017 but with a significant amount of missing HS-codes.

As a result, we obtain a benchmark change in unique measures of each country – $N^{\text{unq}}_{\Delta B,dk}$:

$$N^{\text{unq}}_{\Delta B,dk} = \sum_p \hat{\beta}^p N^p_{\Delta,dk}$$

Since NTMTRAINS contains information about when specific measure types entered into force, we are able to compare $N^{\text{unq}}_{\Delta B,dk}$ to actual changes in the data and identify outliers of "excessive" regulatory change (see Section 2.2 and Appendix C). For this, we construct a sector-specific minimum threshold value $N^{\text{unq, min}}_{\Delta,dk}$ defined by $Q1-1.5*IQR$ with $Q1$ and IQR the first quartile and interquartile range of ($N^{\text{unq}}_{\Delta B,dk}$), respectively. Any changes in the actual data that are smaller than the minimum threshold value, $N^{\text{unq}}_{\Delta,dk} < N^{\text{unq, min}}_{\Delta,dk}$, are replaced by $N^{\text{unq}}_{\Delta B,dk}$, resulting in a final change in unique measure types imposed by each country d. To reflect that we generally trust information on NTMs that are phased-out over time we do not set a maximum threshold value.

2. **Changes in harmonization events**

We pool across all sectors k to estimate the following model via OLS:

$$N^{\text{har}}_{odk} = \sum_p \beta^p N^p_{odk} + \delta_d + \gamma_o + \alpha_k + \varepsilon_{odk} \tag{H.2}$$

$$\text{with} \quad p \in \left\{ N^{\text{unq}}_{dk}, N^{\text{unq}}_{ok}, N^{\text{har},ND}_{odk}, N^{\text{har},NR}_{odk}, N^{\text{div},ND}_{odk}, N^{\text{div},NR}_{odk}, \right\}$$

N^{har}_{odk} are the average number of common measure types between countries o and d in 2017. These are a function of neighboring and reference countries harmonization, and the unique number of measures imposed by countries o and d. We further let the average number of measure types imposed by country d but not by o (i.e. divergence) be a determinant of harmonization. The benchmark regulatory change for harmonization is defined by:[41]

$$N^{\text{har}}_{\Delta B,odk} = \sum_p \hat{\beta}^p N^p_{\Delta,odk}$$

Note that $N^{\text{unq}}_{\Delta,dk}$ and $N^{\text{unq}}_{\Delta,ok}$ are the final values derived in the previous step. The definition of a minimum threshold value and construction of final $N^{\text{har}}_{\Delta,odk}$ is analogous to $N^{\text{unq}}_{\Delta,dk}$.

[41] By design of regression equation (H.2), $N^{\text{har}}_{\Delta B,odk}$ is asymmetric. To obtain a symmetric benchmark change we average $N^{\text{har}}_{\Delta B,odk}$ over a symmetric origin-destination-sector identifier.

3. **Changes in divergence events**

   We follow the same steps as for harmonization and estimate regression model (H.2) with the average number of divergence events between countries' o and d (N^{div}_{odk}) as dependent variable.

   Since N^{div}_{odk} is an asymmetric indicator and is significantly impacted by regulatory changes in the origin country, as well, we set a minimum and maximum threshold value to identify outliers, with $N^{\text{div, max}}_{\Delta,odk}$ defined by $Q3 + 1.5 * IQR$. This prevents high divergence values if country o introduced an excessively high number of measure types between 2012 and 2017.

4. **Changes in regulatory difference & consistency check**

   The final change in regulatory differences is defined by: $N^{\text{dif}}_{\Delta,odk} = N^{\text{har}}_{\Delta,odk} - N^{\text{div}}_{\Delta,odk}$

   We impose consistency checks on final changes in harmonization and divergence in that a) two countries cannot harmonize more or less than the sum of changes in unique measure types ($N^{\text{unq}}_{\Delta,ok} + N^{\text{unq}}_{\Delta,dk}$), and b) two countries cannot diverge more or less than the sum of absolute changes in unique measure types ($|N^{\text{unq}}_{\Delta,ok}| + |N^{\text{unq}}_{\Delta,dk}|$).

H.3 Imputed values of regulatory change

We compare imputed regulatory changes, i.e. $N^{i}_{\Delta,B}$, to actual regulatory changes in the data for a set of countries for which NTM data were collected in 2017 and 2012. The eleven countries are: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, European Union, Mexico, Paraguay, Peru, Uruguay. Table 19 summarizes average regulatory changes in the data (Mean), imputed changes based on the procedure outlined above (Imputed), and the p-value of a paired t-test for the difference in means between actual and imputed regulatory changes of these eleven countries.

With respect to regulatory stringency, Table 19 demonstrates that imputed regulatory changes are not statistically different from actual ones in the data. Thus, we are confident that the imputed values of N^{str}_{Δ} used for all countries in the analysis are a suitable reflection of actual regulatory changes between 2012 and 2017. For harmonization and divergence the benchmark changes are statistically different in most sectors. Generally, the imputed values suggest more harmonization events and fewer divergence events compared to actual changes in the data. Thus, we are likely to identify too few observations with a relatively high number of harmonization events and too many observations with a relatively high number of divergence events as outliers. Regarding imputed values that replace outliers, we most likely model too many harmonization relative to divergence events.

Table 20 lists the share of imputed regulatory difference values in the number of observations for which we simulate non-zero regulatory-difference-induced trade cost changes.[42] Overall, 44% of pairwise non-zero regulatory difference-based trade cost changes (28% of total sample) are based on imputed changes in regulatory differences. 60% of these involve one of the 14 outlier countries as origin or destination.

Table 19: Real and imputed regulatory changes (2017 to 2012) for selected countries

	Stringency			Harmonization			Divergence		
	Mean	Imputed	P-value	Mean	Imputed	P-value	Mean	Imputed	P-value
Grains	-8.00	-8.15	0.97	-1.19	-1.27	0.74	-0.64	-0.32	0.30
Veg & Fruits	-4.98	-5.57	0.77	-0.54	-0.74	0.16	-0.63	-0.33	0.05
Crops	-2.93	-2.99	0.96	-0.40	-0.57	0.11	-0.30	-0.21	0.31
Animal	-2.97	-2.56	0.70	-0.26	-0.42	0.05	-0.31	-0.17	0.09
Extr Nrg	-0.40	-0.36	0.53	-0.04	-0.11	0.00	-0.15	-0.10	0.04
Food Anm	-4.35	-4.65	0.88	-0.67	-0.74	0.57	-0.42	-0.31	0.57
Food Plant	-3.28	-3.62	0.80	-0.37	-0.68	0.01	-0.49	-0.30	0.17
Tex	-0.57	-0.36	0.45	-0.17	-0.33	0.00	-0.43	-0.12	0.00
Light Mfc	-0.39	-0.26	0.24	-0.04	-0.10	0.00	-0.16	-0.09	0.01
Chem	-0.43	-0.63	0.19	-0.05	-0.25	0.00	-0.11	-0.10	0.41
Pharma	-1.78	-1.88	0.85	-0.17	-0.33	0.01	-0.18	-0.14	0.38
Plastics	-0.35	-0.15	0.35	-0.04	-0.11	0.00	-0.19	-0.06	0.00
Mineral	-0.26	-0.14	0.49	-0.03	-0.14	0.00	-0.25	-0.05	0.00
Metal	-0.32	-0.07	0.34	-0.02	-0.06	0.00	-0.14	-0.02	0.00
Metal products	-0.18	-0.08	0.34	-0.04	-0.06	0.24	-0.16	-0.03	0.00
Electr Comp	-0.51	-0.28	0.30	-0.13	-0.16	0.34	-0.25	-0.10	0.00
Electr Eq	-0.90	-0.50	0.27	-0.39	-0.32	0.46	-0.41	-0.12	0.00
Machinery	-0.50	-0.32	0.44	-0.18	-0.27	0.24	-0.32	-0.11	0.00
Transport	-0.13	-0.08	0.29	-0.05	-0.05	0.99	-0.06	-0.02	0.04
Auto	-0.51	-0.32	0.23	-0.15	-0.16	0.72	-0.13	-0.07	0.22

Note: 1) P-value of a paired t-test for difference in means.

[42] The 14 countries in bold are identified as outliers in Table 18.

Table 20: Imputation summary

	Dif (d)	Dif (o)		Dif (d)	Dif (o)		Dif (d)	Dif (o)
AFG	0.06	0.57	GIN	0.20	0.55	NZL	0.22	0.47
ARE	0.29	0.41	**GTM**	0.62	0.55	OMN	0.41	0.45
ARG	0.34	0.34	HKG	0.22	0.55	PAK	0.22	0.48
AUS	0.58	0.35	**HND**	0.31	0.51	**PAN**	0.43	0.48
BEN	0.40	0.48	IDN	0.38	0.36	PER	0.29	0.34
BFA	0.05	0.58	IND	0.35	0.30	PHL	0.36	0.32
BGD	0.62	0.46	ISR	0.37	0.47	PRY	0.09	0.42
BHR	0.28	0.33	JAM	0.13	0.53	PSE	0.27	0.39
BLR	0.87	0.58	**JOR**	0.42	0.48	QAT	0.18	0.47
BOL	0.11	0.40	**JPN**	0.83	0.48	**RUS**	0.85	0.58
BRA	0.36	0.21	**KAZ**	0.89	0.58	SAU	0.48	0.28
BRN	0.41	0.49	**KGZ**	0.91	0.64	SEN	0.05	0.59
BWA	0.06	0.58	KHM	0.30	0.45	SGP	0.26	0.44
CAN	0.33	0.30	**KOR**	0.92	0.64	**SLV**	0.17	0.43
CHE	0.46	0.31	KWT	0.37	0.38	TGO	0.10	0.59
CHL	0.43	0.32	LAO	0.32	0.52	THA	0.35	0.36
CHN	0.88	0.29	LBN	0.22	0.43	**TJK**	0.46	0.40
CIV	0.00	0.59	LKA	0.41	0.42	TTO	0.19	0.56
CMR	0.11	0.58	MAR	0.55	0.37	TUN	0.21	0.53
COL	0.15	0.30	MEX	0.38	0.35	TUR	0.53	0.41
CRI	0.71	0.49	MUS	0.32	0.40	URY	0.13	0.39
DZA	0.41	0.37	MYS	0.41	0.46	USA	0.54	0.30
ECU	0.60	0.29	NER	0.17	0.54	**VEN**	0.82	0.54
ETH	0.42	0.39	NGA	0.30	0.47	VNM	0.61	0.51
EU28	0.49	0.23	NIC	0.15	0.37	ZWE	0.01	0.56
GHA	0.29	0.41	NPL	0.04	0.60			

I Trade cost changes

Table 21: Trade-weighted changes in trade costs by country and scenario

	Destination					*Origin*				
	Dif	Str – HET	All	Str – SI	Imp	Dif	Str – HET	All	Str – SI	Imp
AFG	-1.51	0.00	-1.51	0.00	-8.04	-0.24	0.10	-0.14	0.05	-0.81
ARE	-0.80	-0.10	-0.90	-0.04	-1.50	-0.01	0.06	0.04	0.07	0.00
ARG	-0.29	-0.03	-0.32	0.02	-0.60	4.01	0.85	4.83	0.83	1.46
AUS	-1.50	0.51	-0.97	0.21	-1.43	-0.85	0.09	-0.76	0.35	-1.09
BEN	1.31	0.23	1.50	0.74	0.92	-2.48	0.04	-2.44	0.02	-3.69
BFA	-0.22	0.00	-0.22	0.00	-2.94	0.82	0.10	0.92	0.07	1.02
BGD	-2.66	0.14	-2.51	0.19	-3.99	-1.02	-0.25	-1.27	-0.13	-1.93
BHR	-0.66	0.09	-0.59	0.29	-1.11	-0.27	0.09	-0.17	0.10	-0.24
BLR	-1.29	-0.20	-1.49	-0.04	-2.50	-2.72	-0.17	-2.89	0.28	-3.86
BOL	-0.73	-0.05	-0.78	-0.01	-2.32	1.15	0.13	1.22	0.16	0.67
BRA	-0.28	-0.02	-0.28	-0.15	-0.48	-2.36	-2.75	-5.13	0.44	-4.59
BRN	-0.69	0.00	-0.69	0.00	-1.85	0.01	-0.01	0.00	-0.01	-0.01
BWA	-0.11	0.00	-0.11	-0.03	-0.88	0.19	0.00	0.19	0.02	0.04
CAN	-1.18	0.39	-0.79	0.19	-0.99	0.77	0.43	1.21	0.11	1.12
CHE	-0.17	-0.14	-0.31	0.04	-0.45	0.42	0.07	0.49	0.14	0.23
CHL	0.74	0.14	0.88	0.34	-0.25	1.27	0.90	2.11	0.27	1.52
CHN	-0.38	-0.73	-1.10	0.01	-1.39	-1.69	-0.08	-1.76	0.11	-2.74
CIV	0.02	0.00	0.02	0.00	-5.91	6.03	0.07	6.09	0.08	-0.30
CMR	-0.42	0.00	-0.42	0.00	-5.60	1.20	0.07	1.27	0.04	0.27
COL	-1.78	0.16	-1.61	0.21	-2.11	0.41	0.07	0.49	0.02	0.55
CRI	-0.82	0.42	-0.37	0.46	-0.53	-5.09	1.60	-3.45	0.43	-4.35
DZA	-2.13	0.00	-2.13	0.00	-5.01	0.00	0.00	0.00	0.00	0.00
ECU	2.63	0.58	3.06	0.39	1.99	-15.80	0.78	-14.90	0.75	-15.25
ETH	-0.66	0.27	-0.37	0.47	-1.98	-10.95	-0.67	-11.70	0.15	-9.13
EU28	-0.81	-0.04	-0.84	0.21	-0.91	-0.66	0.07	-0.60	0.07	-0.79
GHA	-1.87	0.14	-1.73	0.20	-2.88	0.36	0.12	0.48	0.04	0.04
GIN	-0.69	0.00	-0.69	0.00	-3.47	0.39	0.07	0.45	0.02	0.23
GTM	-1.24	0.34	-0.90	0.56	-0.63	-4.78	1.57	-3.11	0.31	-1.24
HKG	-0.70	0.00	-0.70	0.00	-3.98	0.67	0.32	0.98	0.18	0.52
HND	-0.48	0.27	-0.18	0.51	-1.52	-9.94	1.20	-8.61	0.25	-11.93
IDN	-0.30	0.08	-0.21	0.13	-0.86	-3.49	0.04	-3.43	0.13	-3.46
IND	-1.18	0.03	-1.14	0.03	-0.96	0.03	-0.04	0.00	0.08	-0.52
ISR	-1.07	0.00	-1.07	0.01	-2.64	0.68	-0.05	0.63	0.04	-0.07
JAM	-0.37	0.00	-0.37	0.00	-3.85	3.92	0.36	4.27	0.22	-0.42
JOR	-0.05	0.29	0.23	0.23	-1.26	-3.69	-0.07	-3.76	-0.06	-3.82
JPN	-0.83	0.11	-0.74	0.19	-1.06	-0.44	0.53	0.11	0.00	0.54
KAZ	-2.61	-0.20	-2.81	0.01	-3.73	-0.61	0.02	-0.59	0.02	-1.00
KGZ	-1.42	-0.21	-1.63	0.03	-3.06	-2.70	0.41	-2.28	0.35	-2.10
KHM	-1.43	0.00	-1.44	0.00	-2.71	0.64	-0.16	0.48	-0.09	-0.47
KOR	-1.57	0.08	-1.47	0.20	-1.48	-2.19	0.01	-2.17	0.00	-2.38
KWT	-1.47	-0.01	-1.48	-0.01	-2.16	-0.02	-0.01	-0.04	-0.02	-0.03
LAO	-1.65	-0.01	-1.66	0.04	-1.70	-0.33	-0.02	-0.35	-0.02	-0.68
LBN	-1.52	0.00	-1.53	0.03	-3.00	0.14	0.61	0.75	0.20	0.64
LKA	-0.38	0.19	-0.19	0.19	-2.79	0.60	0.20	0.79	0.05	-0.03
MAR	-1.04	0.13	-0.91	0.30	-1.66	-4.67	0.02	-4.62	0.14	-4.86
MEX	-0.33	0.21	-0.12	0.10	-1.15	0.87	1.32	2.15	0.23	3.03
MUS	-1.34	0.00	-1.34	0.00	-2.38	-1.49	0.45	-1.00	0.09	1.80
MYS	-1.18	-0.10	-1.28	-0.03	-2.83	0.37	0.05	0.42	0.12	-0.27
NER	-0.21	0.00	-0.21	0.00	-3.93	3.09	-0.14	2.95	-0.22	-0.08

	Destination					*Origin*				
	Dif	Str – HET	All	Str – SI	Imp	Dif	Str – HET	All	Str – SI	Imp
NGA	-0.95	-0.02	-0.97	-0.02	-2.55	-0.03	0.01	-0.01	0.01	0.00
NIC	-3.33	0.06	-3.27	0.19	-3.58	-0.13	0.52	0.39	1.67	0.35
NPL	-0.01	0.00	-0.01	0.00	-2.79	0.93	-0.06	0.86	-0.01	0.32
NZL	-3.17	-0.53	-3.75	-0.69	-7.03	8.39	0.44	8.70	2.65	0.16
OMN	-0.66	0.01	-0.66	0.06	-1.84	0.02	-0.02	0.00	-0.01	-0.21
PAK	-0.06	-0.03	-0.09	0.08	-2.42	0.74	-0.06	0.65	-0.03	-0.82
PAN	-0.66	0.11	-0.54	0.30	-1.11	-3.87	-0.08	-3.94	-0.07	-4.20
PER	0.04	0.08	0.10	0.09	0.44	-1.58	0.80	-0.76	0.15	-3.19
PHL	-1.91	-0.03	-1.92	0.09	-1.56	-1.22	0.46	-0.74	0.23	-1.65
PRY	-0.53	0.00	-0.53	0.00	-2.26	2.69	0.26	2.91	0.80	-0.57
PSE	-2.13	0.01	-2.12	0.00	-2.35	-0.82	0.20	-0.61	0.28	0.76
QAT	-0.56	0.00	-0.56	-0.04	-2.90	0.01	-0.03	-0.02	-0.03	-0.03
RUS	-2.66	-0.28	-2.94	0.05	-3.56	-0.84	-0.04	-0.88	0.01	-1.20
SAU	-1.01	0.11	-0.89	0.53	-0.97	-0.17	-0.07	-0.24	-0.07	-0.25
SEN	-0.24	0.00	-0.24	0.00	-4.11	2.91	0.24	3.11	0.04	0.07
SGP	-0.62	0.00	-0.62	0.00	-1.73	0.30	0.00	0.30	-0.02	-0.47
SLV	-0.32	0.24	-0.09	0.92	-1.19	-3.36	0.23	-3.13	0.24	-3.21
TGO	-0.53	0.00	-0.53	0.00	-3.26	1.37	0.02	1.39	0.04	-0.10
THA	-1.24	0.06	-1.18	-0.05	-1.98	0.38	0.07	0.46	0.13	-0.07
TJK	-3.40	0.04	-3.36	0.24	-4.60	-1.81	0.13	-1.68	0.08	-0.98
TTO	-0.67	0.00	-0.67	0.00	-3.78	0.09	-0.23	-0.14	-0.26	-0.86
TUN	-0.57	0.00	-0.57	0.00	-2.97	1.09	-0.10	1.00	0.22	0.29
TUR	-0.26	0.00	-0.26	0.00	-0.67	0.00	0.19	0.19	0.28	-0.06
URY	-0.73	0.04	-0.68	-0.12	-2.00	5.71	0.20	5.86	2.20	2.99
USA	-0.38	0.52	0.13	0.10	0.37	-0.71	-0.17	-0.86	0.16	-1.18
VEN	-0.71	0.22	-0.46	0.47	-0.20	-0.16	0.00	-0.16	-0.01	-0.05
VNM	-1.58	0.63	-0.90	0.57	-2.74	-3.43	0.05	-3.35	0.13	-4.37
ZWE	-0.04	0.02	-0.02	0.01	-4.80	6.71	0.30	7.01	0.07	2.50

J Changes in trade

Table 22: Changes in trade between regions and income level (in %)

	High	UM	LM	Low	EAP	ECA	LAC	MENA	NA	SA	SSA	Total
Panel I: Dif – HET												
High	0.28	0.99	-0.17	0.69	1.13	0.29	-0.88	0.32	0.12	0.25	-0.14	0.46
UM	0.77	0.98	0.69	1.18	1.82	1.26	-1.01	-0.18	-0.02	0.29	-0.22	0.81
LM	0.01	1.22	2.39	0.29	1.32	0.46	-1.19	0.88	-1.29	2.66	0.68	0.54
Low	1.80	-3.29	0.76	-3.03	-2.50	2.49	-1.62	2.16	-1.33	0.19	-1.44	0.50
EAP	1.42	1.39	0.00	0.56	1.34	1.68	-0.56	0.16	1.47	0.52	-0.59	1.22
ECA	0.12	1.68	0.07	0.97	2.02	-0.01	-1.00	-0.20	0.54	0.29	-0.18	0.57
LAC	-1.21	0.07	2.96	-2.67	0.69	2.98	-1.40	1.76	-2.43	2.00	3.01	-0.64
MENA	-0.11	0.15	-0.04	1.27	0.06	-0.27	-0.73	0.94	-0.63	-0.07	0.43	-0.04
NA	-0.03	0.00	1.79	1.90	1.56	0.30	-0.94	0.85	-1.04	1.90	0.73	0.08
SA	0.62	0.14	1.20	0.01	0.91	0.84	-1.26	0.30	0.51	0.38	-0.28	0.57
SSA	-0.37	-1.83	0.86	0.98	-1.17	-0.21	-1.78	1.71	-1.75	0.59	0.62	-0.31
Total	0.43	1.00	0.36	0.73	1.33	0.68	-0.93	0.27	-0.03	0.55	-0.07	0.58
Panel II: Str – HET												
High	-0.73	-0.61	-0.09	-0.29	-0.42	-0.16	-1.64	0.06	-1.39	-0.06	-0.17	-0.63
UM	-0.41	0.53	-0.01	-0.38	0.16	0.36	-0.47	0.02	-1.15	0.07	-0.20	-0.18
LM	-0.02	0.07	-0.05	-0.13	-0.44	0.44	-0.03	-0.20	0.30	0.00	-0.23	0.00
Low	0.26	-3.79	0.66	0.08	-3.88	0.03	-0.29	1.16	0.90	0.52	0.38	-0.45
EAP	-0.14	-0.70	0.16	-0.39	-0.63	0.60	-0.44	0.20	-0.27	0.16	-0.14	-0.25
ECA	0.11	0.11	-0.12	-0.17	-0.19	0.10	-0.12	0.08	0.54	-0.24	-0.11	0.09
LAC	-2.00	1.42	-0.74	-0.59	1.83	-0.72	-0.44	-0.28	-2.70	-0.27	-0.47	-1.06
MENA	-0.08	0.30	-0.03	-0.28	0.03	-0.10	-0.07	0.16	0.02	0.03	-0.20	0.01
NA	-1.97	-0.96	-0.81	-0.58	0.22	-0.49	-2.61	-0.56	-3.91	-0.36	-0.54	-1.63
SA	0.31	0.01	-0.34	-0.12	-0.57	0.58	0.13	-0.18	0.70	0.17	-0.19	0.20
SSA	-0.04	-1.04	0.14	-0.10	-1.48	-0.09	0.20	0.48	0.31	0.14	0.03	-0.16
Total	-0.55	-0.29	-0.06	-0.28	-0.27	0.10	-1.22	0.03	-1.18	-0.01	-0.18	-0.43

Note: 1) Panel I: Dif – HET are trade flow changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). Trade cost changes caused by changes in regulatory differences only. Panel II: Str – HET are trade flow changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). Trade cost changes caused by changes in regulatory stringency only.

Table 23: Changes in trade volume by region and income level (in billion USD)

	High	UM	LM	Low	EAP	ECA	LAC	MENA	NA	SA	SSA	Total
Net total effects												
Imports												
Total	-10.2	28.7	4.3	0.3	57.0	26.4	-25.3	2.5	-40.7	3.5	-0.4	23.1
Goods	-11.9	26.2	4.4	0.3	51.8	23.6	-23.0	2.7	-39.7	3.7	-0.2	18.9
Agri-food	17.4	7.5	9.5	0.2	11.0	17.2	-0.5	2.4	-0.6	4.6	0.5	34.5
Manufactures	-30.0	17.5	-4.9	0.1	40.2	5.8	-22.3	0.3	-39.8	-0.8	-0.6	-17.3
Exports												
Total	-13.2	29.6	6.6	0.0	56.9	23.6	-20.5	-0.3	-39.3	3.6	-0.8	23.1
Goods	-15.8	28.7	6.1	0.0	56.4	25.8	-23.0	-0.8	-41.5	3.0	-1.0	18.9
Agri-food	1.2	20.5	12.9	-0.1	21.7	2.0	5.1	1.9	5.9	-0.5	-1.5	34.5
Manufactures	-18.3	8.5	-7.5	0.0	34.7	24.0	-28.6	-2.3	-48.7	3.4	0.3	-17.3
Direct effects												
Imports												
Total	-7.8	30.6	7.3	0.3	53.6	23.4	-17.0	5.8	-40.0	4.2	0.6	30.5
Goods	-7.8	30.6	7.3	0.3	53.6	23.4	-17.0	5.8	-40.0	4.2	0.6	30.5
Agri-food	17.8	7.6	9.4	0.2	11.0	17.4	-0.3	3.1	-1.4	4.7	0.6	35.0
Manufactures	-25.6	23.1	-2.1	0.1	42.6	6.0	-16.6	2.7	-38.5	-0.5	0.0	-4.5
Exports												
Total	-13.5	37.9	6.1	0.0	67.5	28.3	-24.9	-0.5	-41.1	2.6	-1.4	30.5
Goods	-13.5	37.9	6.1	0.0	67.5	28.3	-24.9	-0.5	-41.1	2.6	-1.4	30.5
Agri-food	0.7	20.8	13.6	0.0	22.0	2.0	4.5	2.0	6.2	-0.2	-1.4	35.0
Manufactures	-14.2	17.2	-7.5	0.0	45.5	26.4	-29.4	-2.6	-47.3	2.8	0.0	-4.5
Indirect effects												
Imports												
Total	-2.4	-2.0	-3.0	0.0	3.5	3.0	-8.3	-3.2	-0.7	-0.6	-1.0	-7.4
Goods	-4.1	-4.5	-3.0	0.0	-1.8	0.2	-6.0	-3.0	0.2	-0.5	-0.7	-11.6
Agri-food	-0.4	-0.1	0.1	0.0	0.0	-0.2	-0.1	-0.7	0.8	-0.1	-0.1	-0.5
Manufactures	-4.4	-5.6	-2.8	0.0	-2.3	-0.2	-5.7	-2.4	-1.3	-0.3	-0.6	-12.8
Exports												
Total	0.3	-8.3	0.5	0.0	-10.7	-4.7	4.4	0.2	1.8	1.0	0.6	-7.4
Goods	-2.3	-9.3	0.0	0.0	-11.1	-2.5	1.9	-0.3	-0.4	0.4	0.4	-11.6
Agri-food	0.5	-0.3	-0.7	0.0	-0.3	0.0	0.6	-0.1	-0.3	-0.3	0.0	-0.5
Manufactures	-4.2	-8.7	0.0	0.0	-10.8	-2.4	0.8	0.3	-1.5	0.5	0.2	-12.8

Note: 1) Trade flow changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). We sum trade cost changes caused by changes in regulatory stringency and difference. 2) Direct effects are changes in trade flows affected by trade cost changes and indirect effects are changes in trade flows not affected by changes in trade costs. 3) Total: includes services, energy and extraction sectors; Agri-food and Manufactures exclude energy and extraction sectors.

K Real income changes

Table 24: Change in real income by scenario (in %)

	All			Structure		Stringency		Combined		Imp
	$\tilde{f}^{s,\tau}, \tilde{f}^{s,\text{imp}}, \tilde{f}^{s,\text{exp}}$	$\tilde{f}^{s,\tau}, \tilde{f}^{s,\text{imp}}$	$\tilde{f}^{s,\tau}$	$\tilde{f}^{s,\tau}, \tilde{f}^{s,\text{imp}}, \tilde{f}^{s,\text{exp}}$	$\tilde{f}^{s,\tau}$	$\tilde{f}^{s,\tau}, \tilde{f}^{s,\text{imp}}$	$\tilde{f}^{s,\tau}$	$\tilde{f}^{s,\tau}, \tilde{f}^{s,\text{imp}}$	$\tilde{f}^{s,\tau}$	$\tilde{f}^{s,\tau}, \tilde{f}^{s,\text{imp}}, \tilde{f}^{s,\text{exp}}$
AFG	0.48	0.28	0.76	0.44	0.72	0.04	0.04	0.00	0.01	2.26
ARE	0.27	0.19	0.48	0.28	0.45	-0.01	0.03	-0.02	0.01	0.41
ARG	-0.24	-0.47	-0.31	-0.11	-0.19	-0.10	-0.11	-0.04	-0.02	-0.15
AUS	0.17	0.15	0.27	0.22	0.39	-0.04	-0.12	-0.05	-0.07	0.21
BEN	-0.75	0.14	0.02	-0.51	0.33	-0.22	-0.33	-0.31	-0.61	-0.88
BFA	-0.02	-0.10	-0.04	0.04	0.02	-0.05	-0.05	-0.01	-0.01	0.62
BGD	0.41	0.35	0.61	0.38	0.60	0.04	0.02	0.02	0.00	0.64
BHR	0.17	0.25	0.36	0.21	0.42	-0.05	-0.07	-0.11	-0.20	0.27
BLR	0.95	1.06	1.98	0.82	1.67	0.13	0.30	-0.04	0.04	1.52
BOL	0.19	-0.06	0.12	0.20	0.13	-0.02	-0.01	-0.02	-0.01	0.42
BRA	0.08	0.14	0.12	0.02	0.07	0.07	0.06	-0.02	-0.01	0.06
BRN	0.33	0.28	0.46	0.32	0.44	0.02	0.02	0.00	0.00	0.77
BWA	0.04	0.04	0.05	0.03	0.04	0.01	0.01	-0.01	0.00	0.13
CAN	0.11	-0.07	0.11	0.26	0.32	-0.15	-0.21	-0.06	-0.07	0.13
CHE	0.02	-0.01	-0.02	-0.02	-0.08	0.03	0.06	-0.03	-0.05	0.25
CHL	-0.27	-0.35	-0.42	-0.15	-0.33	-0.13	-0.10	-0.06	-0.11	-0.11
CHN	0.25	0.30	0.51	0.14	0.30	0.10	0.21	0.00	0.00	0.34
CIV	-0.66	-1.18	-0.89	-0.67	-0.90	0.01	0.01	-0.01	-0.01	0.59
CMR	-0.06	-0.13	-0.10	-0.04	-0.08	-0.01	-0.01	-0.01	0.00	0.65
COL	0.17	0.08	0.26	0.18	0.28	0.00	-0.02	-0.01	-0.03	0.19
CRI	0.18	0.39	0.42	0.37	0.64	-0.18	-0.21	-0.10	-0.18	0.18
DZA	0.74	0.61	1.05	0.72	1.03	0.01	0.02	0.00	0.00	1.33
ECU	0.41	1.59	1.02	0.47	1.15	-0.07	-0.15	-0.05	-0.09	0.37
ETH	0.25	0.37	0.29	0.36	0.46	-0.10	-0.17	-0.05	-0.10	0.44
EU28	0.13	0.12	0.21	0.12	0.19	0.01	0.01	-0.01	-0.03	0.12
GHA	0.33	0.13	0.55	0.39	0.65	-0.06	-0.08	-0.07	-0.11	0.57
GIN	0.30	0.17	0.47	0.30	0.46	0.00	0.01	-0.02	-0.02	1.67
GTM	0.06	0.14	0.26	0.20	0.43	-0.14	-0.15	-0.02	-0.12	-0.14
HKG	0.27	0.16	0.43	0.29	0.44	-0.02	-0.01	-0.03	-0.03	1.41
HND	0.24	0.62	0.69	0.53	1.06	-0.27	-0.29	-0.18	-0.38	0.34
IDN	0.02	0.17	0.18	0.03	0.19	-0.01	-0.01	-0.02	-0.04	0.06
IND	0.14	0.11	0.22	0.14	0.22	0.00	0.00	0.00	0.00	0.10
ISR	0.16	0.11	0.22	0.15	0.19	0.01	0.02	-0.01	0.00	0.55
JAM	0.00	-0.24	0.05	0.13	0.16	-0.13	-0.12	-0.08	-0.06	2.22
JOR	-0.13	0.12	-0.12	-0.09	0.07	-0.05	-0.20	-0.03	-0.18	0.37
JPN	0.07	0.08	0.18	0.12	0.21	-0.05	-0.04	-0.04	-0.05	0.07
KAZ	0.41	0.37	0.77	0.39	0.71	0.02	0.06	-0.01	-0.01	0.53
KGZ	0.72	0.38	1.66	0.56	1.24	0.17	0.45	-0.11	-0.06	1.50
KHM	1.04	0.65	1.59	0.94	1.50	0.11	0.09	0.07	0.08	1.83
KOR	0.71	0.71	1.14	0.75	1.23	-0.02	-0.02	-0.06	-0.11	0.75
KWT	0.53	0.43	0.83	0.52	0.81	0.01	0.02	-0.01	0.00	0.66
LAO	0.46	0.27	0.75	0.47	0.77	-0.01	-0.01	0.03	0.01	0.45
LBN	0.57	0.37	0.92	0.59	0.93	-0.02	-0.01	-0.02	-0.03	1.17
LKA	0.00	-0.06	-0.03	0.05	0.05	-0.04	-0.08	-0.02	-0.04	0.66
MAR	0.36	0.58	0.77	0.34	0.78	0.02	-0.02	-0.05	-0.17	0.56
MEX	-0.38	-0.58	-0.45	-0.09	-0.19	-0.28	-0.27	-0.04	-0.06	-0.35
MLI	-0.05	-0.05	-0.06	-0.03	-0.04	-0.02	-0.02	0.01	0.01	-0.01

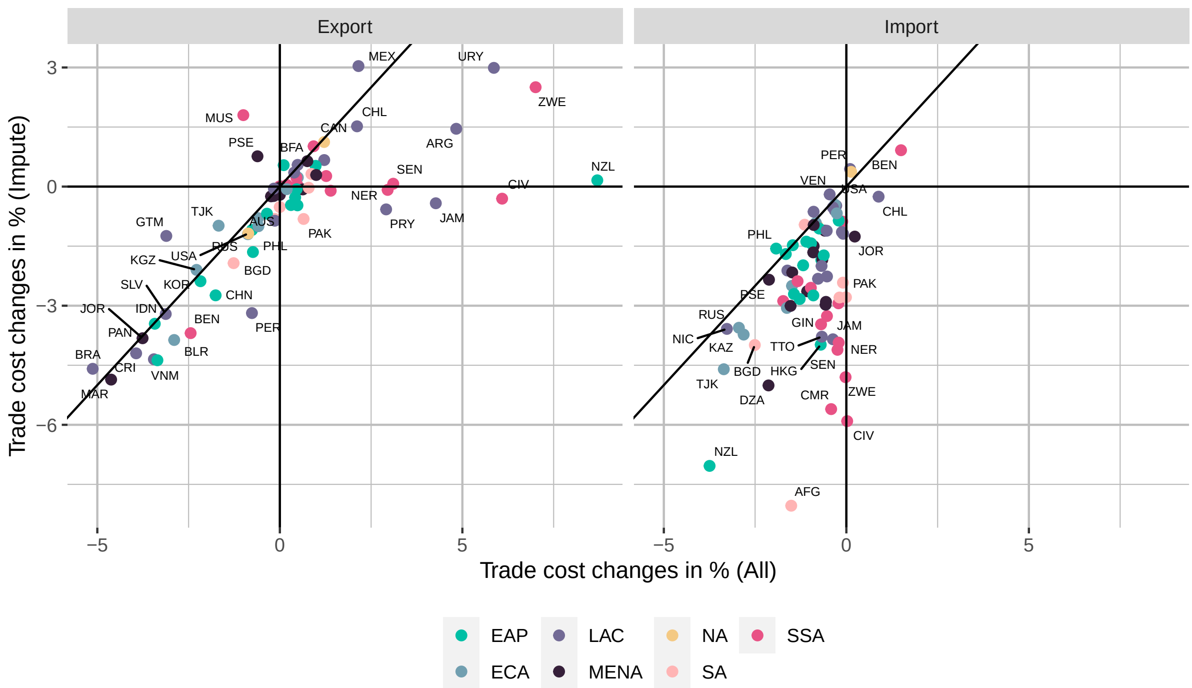
	All			Structure		Stringency		Combined		Imp
	$\tilde{t}^{s,\tau},\tilde{t}^{s,\text{imp}},\tilde{t}^{s,\text{exp}}$	$\tilde{t}^{s,\tau},\tilde{t}^{s,\text{imp}}$	$\tilde{t}^{s,\tau}$	$\tilde{t}^{s,\tau},\tilde{t}^{s,\text{imp}},\tilde{t}^{s,\text{exp}}$	$\tilde{t}^{s,\tau}$	$\tilde{t}^{s,\tau},\tilde{t}^{s,\text{imp}}$	$\tilde{t}^{s,\tau}$	$\tilde{t}^{s,\tau},\tilde{t}^{s,\text{imp}}$	$\tilde{t}^{s,\tau}$	$\tilde{t}^{s,\tau},\tilde{t}^{s,\text{imp}},\tilde{t}^{s,\text{exp}}$
MUS	0.32	0.30	0.59	0.34	0.60	-0.02	-0.01	0.01	0.00	0.45
MYS	0.29	0.03	0.46	0.29	0.41	0.00	0.05	-0.02	-0.01	0.95
NER	-0.07	-0.37	-0.20	0.06	-0.04	-0.11	-0.14	0.00	0.00	0.44
NGA	0.12	0.08	0.18	0.12	0.18	0.00	0.00	0.00	0.00	0.30
NIC	1.35	0.91	2.20	1.41	2.27	-0.07	-0.08	-0.51	-0.43	1.30
NPL	0.04	0.02	0.05	0.03	0.04	0.01	0.00	0.00	0.00	1.04
NZL	0.38	-0.60	0.23	0.37	0.13	0.00	0.07	-0.30	-0.10	0.98
OMN	0.27	0.21	0.38	0.24	0.35	0.03	0.03	-0.01	-0.02	0.60
PAK	0.03	-0.01	0.01	0.02	0.00	0.01	0.01	0.02	0.01	0.36
PAN	0.46	0.62	0.73	0.50	0.81	-0.03	-0.07	-0.14	-0.26	0.68
PER	-0.06	0.02	0.01	0.00	0.06	-0.06	-0.06	-0.01	-0.03	-0.09
PHL	0.29	0.27	0.54	0.33	0.60	-0.04	-0.03	-0.03	-0.08	0.25
PRY	-0.54	-0.93	-0.52	-0.46	-0.46	-0.05	-0.06	-0.12	-0.08	-0.03
PSE	0.51	0.40	0.77	0.50	0.77	0.01	0.00	0.00	0.00	1.02
QAT	0.19	0.17	0.29	0.18	0.28	0.01	0.01	0.00	0.01	0.68
RUS	0.33	0.32	0.61	0.30	0.55	0.03	0.06	-0.01	-0.02	0.40
SAU	0.16	0.15	0.29	0.18	0.33	-0.02	-0.03	-0.09	-0.16	0.22
SEN	0.05	-0.24	0.03	0.13	0.11	-0.06	-0.07	-0.01	0.00	1.60
SGP	0.16	0.11	0.26	0.16	0.20	0.00	0.06	-0.02	0.00	0.74
SLV	0.04	0.17	0.17	0.07	0.27	-0.03	-0.11	-0.09	-0.34	0.33
TGO	0.44	0.10	0.71	0.45	0.73	0.01	0.01	-0.01	0.00	3.18
THA	0.13	-0.03	0.27	0.20	0.33	-0.07	-0.06	-0.02	0.01	0.35
TJK	1.57	1.21	2.72	1.61	2.79	-0.04	-0.06	-0.08	-0.16	2.17
TTO	0.26	0.19	0.40	0.24	0.34	0.02	0.06	0.03	0.07	1.61
TUN	0.04	-0.08	-0.05	-0.06	-0.14	0.10	0.09	0.06	0.03	1.24
TUR	0.05	0.04	0.09	0.07	0.11	-0.03	-0.02	-0.03	-0.03	0.16
URY	-0.39	-0.81	-0.60	-0.14	-0.29	-0.19	-0.25	-0.17	-0.11	-0.07
USA	0.01	0.03	-0.02	0.01	0.03	0.00	-0.04	-0.01	-0.01	0.02
VEN	0.06	0.06	0.09	0.06	0.10	0.00	-0.01	-0.02	-0.04	0.06
VNM	1.11	1.61	1.89	1.41	2.59	-0.25	-0.59	-0.21	-0.54	2.47
ZWE	-0.14	-0.57	-0.31	-0.09	-0.25	-0.04	-0.05	0.00	0.00	0.35

L Imputation scenario

We estimate the impact of regulatory activity that is potentially not captured by NTMTRAINS by using benchmark regulatory change $N^{i}_{\Delta B}$ (see Appendix H) to compute AVE trade cost changes. The implementation follows the results presented in the main text i.e. scenario $\left\{\tilde{t}^{s,\tau}, \tilde{t}^{s,\text{imp}}, \tilde{t}^{s,\text{exp}}\right\}$. Table 25 is analogous to the presentation of changes in trade flows presented in Table 6. Panel I presents the imputation scenario and Panel II reproduces Panel I of Table 6. Figure 5 maps trade cost changes of the main scenario against those based on fully imputed regulatory changes from the importer and exporter perspective. Figure 6 compares macroeconomic outcomes (real GDP and real income) of the main and imputed scenario.

Comparing differences in trade cost changes for imports and exports between the two scenarios (Figure 5) we find that imputed trade cost changes are relatively more liberalizing than those in the base scenario. For exports and imports, trade cost reductions/increases are mostly larger/smaller in the imputation scenario. Particularly, higher imputed regulatory changes for countries in Sub-Saharan Africa lead to significant trade cost reduction relative to the base scenario.

Figure 5: Trade cost changes – All vs. Impute (in %)



Overall, the imputed trade cost changes imply a lower increase of global trade than in the base scenario. With respect to income-level, imports and exports of low and lower-middle income countries increase more in the imputation compared to the base scenario. By contrast, high-income countries' trade decreases in the imputation scenario, while the overall trade effect on upper-middle income countries is similar in both scenarios. On the regional level, the higher trade cost liberalization for Sub-Saharan African countries in the imputed scenario translate into significant increases in trade. This is similarly the case for South Asia. The trend of decreasing trade in the Americas is more pronounced in the imputation scenario.

The macroeconomic and income effects are significantly higher in the imputation scenario (Figure 6), which corresponds to the more liberalizing trade cost changes. Real GDP and income gains are considerably higher for a number of countries in Sub-Saharan Africa, South Asia, and Middle East & North Africa with increases ranging from 1% to 3%.

Table 25: Changes in trade between regions and income level (in %)

	High	UM	LM	Low	EAP	ECA	LAC	MENA	NA	SA	SSA	Total
Panel I: All – HET (Imputed)												
High	-1.25	0.65	0.24	-0.54	1.30	-0.10	-3.41	0.92	-3.50	0.27	-0.04	-0.51
UM	0.46	2.85	2.02	2.45	2.99	1.60	-0.38	0.88	-1.15	1.55	1.13	1.12
LM	1.45	2.39	3.10	1.82	1.66	2.48	-0.07	2.05	1.27	2.98	1.89	1.85
Low	2.01	-5.21	4.05	2.73	-5.34	2.79	-0.58	2.48	2.68	2.72	5.48	1.04
EAP	1.62	1.96	1.10	2.18	1.83	1.87	-0.71	1.87	1.66	1.38	1.02	1.65
ECA	-0.11	2.10	0.38	0.64	1.98	0.02	0.09	1.27	-0.23	-0.83	0.12	0.57
LAC	-3.76	2.52	3.38	2.07	3.65	4.19	-0.41	-0.29	-6.78	2.43	4.74	-1.74
MENA	0.13	0.79	0.82	-0.54	0.43	-0.03	-0.51	1.09	0.00	0.80	1.19	0.37
NA	-3.89	-1.66	1.53	-1.69	1.64	-0.29	-5.35	-1.84	-8.52	1.54	-1.10	-2.99
SA	2.16	1.26	1.90	1.26	1.72	2.51	-2.15	1.35	2.56	2.65	0.31	1.97
SSA	0.34	-0.35	2.28	3.40	-0.45	0.32	1.18	2.45	0.09	1.77	3.18	0.69
Total	-0.40	1.29	1.13	1.05	1.78	0.80	-2.35	1.03	-2.31	1.00	0.61	0.21
Panel II: All – HET												
High	-0.12	0.95	-0.16	0.39	1.23	0.45	-2.22	0.56	-0.89	0.28	-0.30	0.21
UM	0.78	1.68	0.80	0.77	2.28	1.96	-1.24	-0.06	-0.68	0.42	-0.47	0.96
LM	0.13	1.55	2.49	0.09	1.15	1.04	-1.09	0.70	-0.85	2.73	0.38	0.71
Low	2.28	-8.97	1.76	-2.90	-7.97	2.84	-1.85	3.39	-0.26	1.00	-0.85	-0.12
EAP	1.61	1.37	0.17	0.04	1.28	2.68	-0.91	0.32	1.40	0.65	-0.85	1.35
ECA	0.49	2.15	0.15	0.86	2.25	0.29	-0.90	0.09	1.43	0.27	-0.24	0.95
LAC	-2.77	1.26	2.75	-3.20	2.19	2.58	-1.62	1.88	-4.60	2.09	2.73	-1.42
MENA	-0.18	0.65	-0.07	0.91	0.23	-0.35	-0.81	1.21	-0.78	-0.04	0.13	0.02
NA	-1.36	-0.50	1.44	1.42	2.27	0.36	-3.10	0.70	-4.13	1.90	0.33	-0.97
SA	1.15	0.47	0.98	-0.17	0.60	1.67	-0.77	0.18	1.56	0.51	-0.59	0.99
SSA	-0.38	-3.46	1.16	0.82	-3.18	-0.25	-1.62	2.29	-1.51	0.89	0.66	-0.51
Total	0.22	1.15	0.42	0.42	1.50	1.09	-1.88	0.44	-0.81	0.62	-0.27	0.49

Note: 1) Panel I: All – HET (Imputed) are trade flow changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). We sum trade cost changes caused by changes in regulatory stringency and difference. Changes in regulatory differences are imputed. Panel II: All – HET are trade flow changes based on the heterogeneous (HET) effect model, i.e. we control for bilateral regulatory differences in Equation (1). We sum trade cost changes caused by changes in regulatory stringency and difference.

Figure 6: GDP & income – All vs. Impute (in %)