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Revisiting Time as a Trade Barrier: Evidence from a Panel Structural Gravity Model

Abstract

In this paper we revisit the evidence on the effects of time spent on border-crossing procedures for international trade using a theory-consistent structural gravity model. We exploit a rich panel data set including domestic trade flows and employ a recent econometric estimator that exhibits favorable asymptotic properties. The results indicate a significant negative effect of the time required for border procedures that is driven by the time needed for document preparation. We find that an additional day spent on those procedures corresponds to an ad valorem tariff equivalent of 0.82 percentage points. The parameters of our structural model are used to simulate three counterfactual scenarios, quantifying the effect of past and potential future trade facilitation efforts for middle, low and high income countries. Full endowment general equilibrium effects suggest that lower and middle income countries benefit most in all scenarios in terms of trade and welfare. In times of stagnating multilateral and bilateral trade liberalization efforts, unilateral implementation of trade facilitation carries the potential to induce an alternative stimulus for trade and welfare, especially for low and middle income countries.

JEL-Codes: C310, F100, F130.

Keywords: structural gravity model, trade facilitation, counterfactual analysis, time to export and import, middle and low income countries.

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1 Introduction

Among economists it is widely recognized that cross-border trade can improve welfare by increasing the variety of goods, lowering the prices for consumers by exploiting comparative advantages and boosting productivity through competition induced reallocation of resources or increased incentives to innovate (see for example Melitz & Trefler, 2012; Donaldson, 2015). A natural way to facilitating trade and market integration is the reduction in tariff and non-tariff barriers to trade. Several general agreement on tariffs and trade (GATT) and World Trade Organization (WTO) trade rounds led to significant multilateral tariff reductions in the second half of the 20th century, but lost momentum lately, accompanied by an increase in regional trade agreements. As a result of the low levels of tariff and non-tariff barriers, lowering transactions costs of cross-border trade procedures became relatively more important (see Martínez-Zarzoso & Márquez-Ramos, 2008). However, in most recent years the number of new trade agreements and their extent is also falling behind expectations with the Transatlantic Trade and Investment Partnership (TTIP) and the Trans-Pacific Partnership (TPP) being prominent examples. Moreover, the US under President Trump started imposing tariffs outside the rule-based system of the WTO. In light of these recent developments, trade facilitation can be seen as a particular convenient way to boost trade since it can be implemented unilaterally.

According to the WTO definition, trade facilitation in a narrow[1] sense relates to 'the simplification and harmonization of international trade procedures' (see Engman, 2009). The burden of border-crossing procedures on businesses can best be expressed in terms of time spent addressing bureaucratic formalities such as customs clearance or port handling times. Time delays represent a deterrence to trade since capital is expended on storage and transport, goods depreciate either physically (perish) or in market value (technological obsolescence), and uncertainty is increased which may lead to wasted resources to widen safety margins (see Djankov, Freund & Pham, 2010; Bourdet & Persson, 2012; Hummels & Schaur, 2013). Particularly in times of globally organized value chains, timely and certainty in delivery, especially of intermediate parts and components products, are important locational factors (see Ansón, Arvis, Boffa, Helble & Shepherd, 2017). Improving efficiency by reducing the time spent on border procedures may increase trade on the extensive and intensive margins and enhance welfare.

This paper addresses the question how time spent on border procedures impacts trade and welfare. We estimate a structural gravity model augmented by the time spent on border-crossing procedures on trade, using a rich panel dataset provided by Oberhofer & Pfaffermayr (2017) and the measures on time to export and import from the World Banks Doing Business Indicators. Utilizing the estimates and exploiting the structure of the model, we simulate three counterfactual scenarios to quantify the effects of unilateral trade facilitation efforts. In the first scenario, we simulate the impact of past reductions in time spent on border crossing procedures between 2006 and 2012. The second scenario aims at quantifying the impacts of potential future trade facilitation and assumes reductions of the time for border procedures of trade involving middle and low income countries to the mean time between high income countries. Scenario 3 simulates the best practice setting the counterfactuals to the minimum time in 2012. Besides the full endowment general equilibrium effects on welfare, domestic and international trade flows, we can also report estimates for an ad valorem tariff equivalent, since our augmented panel data gravity model includes information on applied most-favored nation tariffs and thus is able to identify the trade elasticity parameter.

In the counterfactual scenarios, we calculate the impacts for two groups of countries, namely high income countries and middle/low income countries (according to the World Bank definition). Grouping by income is motivated from numerous empirical studies that find larger impacts of trade facilitation for developing countries. Persson (2008) finds the largest trade impacts of a reduction of export and import time of one day in South African countries. Freund & Rocha (2011) found that long time delays from moving goods from the factory gate towards the border explain much of Africa's poor export performance. The results in Zaki (2014) point towards tariff equivalents of an additional day needed for exporting (importing) of 0.41% (0.61%) for developed and 0.57% (0.93%) for developing countries. Moreover, descriptive statistics on cross-country trade facilitation indicators, such as the ones shown in this paper, document marked differences between countries by income groups.

Our results point towards significant negative effects of time needed to comply with border-crossing procedures. Evidence on the disaggregate components suggests that the effects are driven by the time spent on documents preparation.

[1] In broader sense it may also cover elements inside the border such as institutional quality, regulatory environment and infrastructure.

We find that an additional day of border-crossing procedures is equivalent to an ad valorem tariff of 0.82 [95% confidence bands: 0.002; 1.64] percentage points. In their pioneering work, Hummels & Schaur (2013) estimated that each day in transit is equivalent to an ad valorem tariff of between 0.6 and 1.2 percent. They identified the customers valuation by relating premiums paid for faster air shipping to time delays in ocean transit using data on US HS6 product imports from 1991-2005. While Hummels & Schaur (2013) estimated the value of a day in transport, we focus on the effects of time spent on border procedures exclusive of port to port shipping time. We obtain an ad valorem tariff equivalent from our structural gravity model by directly estimating the trade elasticity with the most-favored nation tariff, that acts as a direct price shifter. Furthermore, since our estimates are based on bilateral trade flows from 63 countries between 2006-2012, we offer a more general - in terms of geographical coverage - and a more recent estimate. The fact that our mean estimate of the ad valorem tariff equivalent of one day of 0.82 is well in line with the estimates of Hummels & Schaur (2013) who used a quasi-experimental approach, lends support to our more general and structural specification and strengthens claims on the external validity of the results provided by Hummels & Schaur (2013).

In a first scenario, the effects of the realized reductions in the time to prepare documents between 2006 and 2012 is simulated. Our counterfactual results show that especially low and middle income benefited from reductions in time in terms of increasing trade and welfare. The average time reduction in trade between middle/low income countries amounted to 3.4 days, which translates to trade increases of 8 percent corresponding to an ad valorem tariff equivalent of 1.3 percentage points. Taking into account the general equilibrium adjustments, the full endowment trade effect is about half the size of the direct impact resulting in a welfare effect of middle/low income countries of 0.7 percent compared to 0.2 for high income countries. The second scenario illustrated the effects of potential future efforts on trade facilitation by setting the document preparation time of trade flows involving middle/low income countries in 2012 to the mean between high income countries in the same year. This scenario leads to even larger direct effects on trade between middle/low income countries of 20 percent, which is equivalent to a tariff reduction of 3.2 percentage points. The full endowment general equilibrium trade effects are again roughly half of the direct effects. As this scenario assumes no improvements in time to trade between high income countries, their bilateral trade flows decrease by 1.9 percent as a result of trade diversion in equilibrium. Welfare of middle/low income countries in this scenario would increase by 1.54 percent. Despite the significant trade diversion, the counterfactual results for this scenario also points to positive welfare effects of 0.38 in high income countries. Finally, the best practice scenario in which the time is set to the minimum of 2012 shows the highest gains with welfare effects for middle/low income countries at 3.5 and for high income countries at 2.2 percent.

Our work relates to the literature on the relevance of trade costs (see Anderson & van Wincoop, 2004), in particular to the literature on time as a trade barrier (see Djankov et al., 2010; Hummels & Schaur, 2013). The paper also relates to the literature on the potential gains from trade facilitation in terms of trade and welfare (see Wilson, Mann & Otsuki, 2005; Persson, 2008). Since we employ a structural gravity model for the simulation of the welfare effects from increased border efficiency, our work builds upon the new quantitative trade model literature and calculates gains of trade from such models (see Anderson & van Wincoop, 2003; Head & Mayer, 2014; Costinot & Rodriguez-Clare, 2014). As our empirical measures on tariffs, time to export and import are recorded as time-varying country fixed variables, our work is also related to the literature on the estimation of non-discriminatory trade policies in structural gravity models (see Head & Mayer, 2014; Piermartini & Yotov, 2016; Heid, Larch & Yotov, 2017).

The main contribution of our paper is the quantification of the welfare effects of facilitating trade by reducing the time spent on border-crossing procedures employing the new quantitative theory of trade. There is an extensive literature on the effects of trade facilitation on trade flows (see Iwanow & Kirkpatrick, 2009; Hoekman & Nicita, 2011; Portugal-Perez & Wilson, 2012), either analyzing the effects on the extensive margin (Persson, 2013; Beverelli, Neumueller & Teh, 2015) or intensive margin (see Persson, 2008; Freund & Rocha, 2011; Bourdet & Persson, 2012) margin. However, so far no empirical study employing a gravity approach[2] quantified the potential or ex-post welfare effects of such measures. Using the novel Constrained Poisson Pseudo-Maximum Likelihood (CPPML) estimator and the accompanying counterfactual simulations developed in Pfaffermayr (2017), we are also able to report asymptotically unbiased confidence intervals of the counterfactual impacts on trade and welfare and are able to derive a comparable and easy to interpret measure of the effect size in terms of an ad valorem tariff equivalent.

[2] Our work relates to the literature on structural gravity models. For computational general equilibrium studies on the welfare effects of trade facilitation see for instance Decreux & Fontagné (2011) or Perera & Mounter (2017).

The remainder of the paper is organized as follows. Section 2 reviews the results from previous studies on the effects of time costs on trade flows. We restrict the focus on empirical econometric studies that aim at obtaining an elasticity of the intensive margin of trade with respect to the time spent in border crossing procedures or transit on trade flows. Section 3 introduces the empirical specification employed, outlines the methods used for econometric estimation and counterfactual simulation and presents the data used. Section 4 presents the estimation and counterfactual simulation results. A final section concludes.

2 Literature on the Costs of Time to Trade

Trading goods across a border involves numerous steps: arranging for shipment and payment, pre-shipment inspections and customs clearance at exporters port, payment of duties, taxes and tariffs, international transit, technical and health inspections, customs clearance at importers port (see Djankov et al., 2010). If one of the two countries in question is landlocked, some of those procedures may apply for the transit countries passed as well. Besides the fees and charges, these steps involve time-consuming procedures. The additional time spent for border-crossing transactions can be viewed as an additional trade costs since exporting firms capital is bound in transport and storage, goods perish or lose value due to technological obsolescence and if these time delays are uncertain, resources may be wasted to widen safety margins (see Djankov et al., 2010; Bourdet & Persson, 2012; Hummels & Schaur, 2013). Especially when considering the just-in-time nature of parts and components trade in networks of global value chains, timely and certainty in delivery gain in importance (see Ansón et al., 2017).

First time exporters need to acquire information on the procedures, which incurs fixed costs that may prevent those companies entering international markets. Furthermore, even if the fixed costs can be borne by the firm, the associated time delays may be prohibitively high such as to deter trade in time-sensitive products. Persson (2013) showed that decreasing the number of days needed to export a good by 1%, increases exported goods between 0.3 (homogeneous goods) and 0.6 (differentiated goods). Beverelli et al. (2015) studied the impacts on two extensive margins of trade, products exported by destination and export destinations by product and found significant positive effects of trade facilitation. These results demonstrate that the time spent on border-crossing procedures affects the decision to trade and the number of products traded. In line with the focus of this paper, the following short literature review is restricted to empirical work covering the effects of time to trade on the intensive margin. Table 1 provides a quick overview of the empirical work on the impacts of time spent on border procedures. The reviewed studies differ in their underlying sample (single country vs. multi-country), data structure (cross-section vs. panel), methodology (naive, structural gravity model, revenue equation), identification strategy used (none, IV, restricted sample), the time measure used (World Bank Doing Business vs. more disaggregated data), in their reporting of direct effects (semi-elasticities vs. elasticities) and whether they report ad valorem tariff equivalents or not.

Among the ten studies reviewed, four report elasticities of trade with respect to time. Freund & Rocha (2011), using a cross-section dataset with focus on African countries found that a one percent increase in inland transport time to export decreases exports by 7 percent. In a panel PPML gravity framework, Bourdet & Persson (2012) found an elasticity on import time of 0.44. Zaki (2014) found elasticities of 1.2 for import time on imports and 0.7 for export time on exports. While these three studies all used the World Bank Doing Business (WD-DB) variables on time to export and import, Ansón et al. (2017) used information on median delivery time based on United Postal Delivery data. Employing cross-sectional structural gravity model they found a comparatively small elasticity of 0.07 for bilateral trade.

The other six studies reviewed reported semi-elasticities, i.e. the direct effect of a change of one day on trade in percent. Persson (2008) estimated a cross-section gravity model using the WB-DB time variables and found that a one day increase in time to export (imports) decreased exports by 1 (0.5) percent at the sample mean. In a similar study, using a similar method and data, Martínez-Zarzoso & Márquez-Ramos (2008) found semi-elasticities of 0.22 for exports and 0.83 for imports. Djankov et al. (2010) employed a single-difference gravity equation framework on a cross-section of countries and found a semi-elasticity of 1.3 from export time on trade. Hummels & Schaur (2013) used a rich panel data set of exporter-, product- and destination port-specific US ocean and air shipments and applied a difference revenue equation to estimate that a one day increase in ocean transit time reduces ocean relative to air shipments by

0.9 percent. Carballo, Graziano, Schaur & Martincus (2016) used Peruvian firm-level data with information on time between clearance and shipment at customs to estimate the effects of border delay times on trade flows employing a cross-section PPML gravity model. They found a semi-elasticity of 0.4 on firm imports. In a recent study, Heid et al. (2017) estimated a structural panel data PPML gravity model with WB-DB data on time to exports and reported a semi-elasticity of 3.5.[3]

A drawback in the comparison of direct elasticities or semi-elasticities is that the effect size can only be interpreted relative to the sample moments of the time measures used. To mitigate this shortcoming, one may express the effect size using a common reference measure such as ad valorem tariff equivalents (AV-TE), that express the cost of an additional day spent on border crossing procedures in percentage points of a tariff. The four studies that calculated these equivalent measures report values that are in the ranging in between 0.4 and 2 percentage points. Freund & Rocha (2011) calculated that a reduction of one day of inland transport time corresponds to a tariff decrease of 2 percentage points of all importing countries. Hummels & Schaur (2013) estimate that each day in transit is equivalent to an ad valorem tariff of between 0.6 and 2.1 percent. Zaki (2014) found AV-TEs between 0.4 and 0.9, while the AV-TE estimates of Carballo et al. (2016) form the upper bound of the documented effects ranging from 0.7 and 1.6.

In order to interpret the above surveyed results as causal impacts, endogeneity concerns need to be addressed. Djankov et al. (2010) raised two important concerns regarding endogeneity of trade and the time required for border-crossing procedures. First, higher trade volumes are likely to improve trade facilitation procedures in the long run resulting in shorter border delays. Assuming a negative effect of border-crossing procedures on trade, this reverse causality would lead to a downward bias in the estimate. Second, increasing trade flows may lead to congestion effects at the port, customs or bureaucratic administration procedures at least in the short run until capacities can adjust. This second issue would induce an upward bias in the estimate.

In the reviewed literature, half of the studies addressed endogeneity issues by either restricting their sample of traded products, applying IV estimation, or including fixed effects for countries or industries in a difference-in-difference type of framework. Freund & Rocha (2011) restricted their sample to newly traded products (products that haven't been traded prior to their sample period) arguing that these products cannot have had an impact on the historical development of the bureaucratic procedures in place. Applying this identification strategy had no markedly effect on their estimate of time. Persson (2008) instrumented the time to export and import with the respective number of documents needed (also taken from the WD-DB dataset) and received similar results as in their OLS estimations. It is argued that, at least in the short run, the number of documents needed to be prepared should not change given changes in trade flows. Zaki (2014) instrumented the time to export (import) with the number of documents needed to export (import), internet penetration, number of procedures needed to start a business, a corruption index and dummy variables for being landlocked, an island or having a tariff in place. Since Zaki (2014) only report IV-estimates, the study contains no indication on how the estimates are affected. Carballo et al. (2016) exploited their rich dataset and instrumented the border delay times by the number of other ships reaching the port the same day and a randomly assigned custom inspection. The resulting estimates decreased by a factor of 10 (i.e. the negative impact increased). Djankov et al. (2010) restricted the sample to landlocked countries and instrumented the time to export by the respective time measures of neighboring countries. They argue that trade volumes are less likely to affect transit times in neighboring countries where they only account for a smaller share. Applying this instrument nearly doubled the impact of their (ratio-type) time to export measure. A similar strategy has also been followed in Freund & Rocha (2011), finding similar results as in their specification including only newly traded products.

This paper extends the existing evidence on the impacts of facilitating trade by reducing the time spent on border procedures in several ways. We estimate the effects of different components contributing to the the total time to export and import in a panel data structural gravity model on a dataset of 63 countries including domestic trade flows and covering three periods 2006, 2009 and 2012 (three year intervals). As the literature review demonstrated, only two papers so far used a theory-consistent structural gravity framework for estimation, with only one of them (Heid et al., 2017) employing panel data, allowing to control for directional bilateral fixed effects and thus following all recommendations for structural gravity models outlined in Piermartini & Yotov (2016). We extend upon Heid et al. (2017) by using a novel estimator, controlling for a series of flexible time trends and provide counterfactual

[3]Since they applied a PPML model with time to export in levels, the resulting elasticity cannot be interpreted as the direct partial effect of an additional day, since average effects in exponential models also depend on the conditional mean of the other covariates.

simulations of full endowment general equilibrium effects on trade and welfare. The estimator we use in this paper is the constrained PPML (CPPML) estimator (see Pfaffermayr, 2017) that is not affected by the incidental parameter problem. To the best of our knowledge, we are the first to provide (full endowment) general equilibrium estimates on the effects of changes in time to trade on trade and welfare. Furthermore, we derive an ad valorem tariff equivalent measure of the effect size and their uncertainty based on the estimated parameters of the model.

Empirical studies on the intensive margin, so far relied mostly on cross-sectional data and only few of them included domestic trade flows, mainly due to the unavailability of such data. However, as Sellner (2017) showed in Monte Carlo simulations, identification of the effects of non-discriminatory (i.e. time-varying but bilaterally-invariant) trade policy variables without information on domestic trade flows leads to biased estimates. We address this shortcoming by using the panel dataset of Oberhofer & Pfaffermayr (2017) that covers domestic and international trade flows for 63 countries between 2006-2012. Our work therefore also closely relates to Heid et al. (2017), who estimated the effects of an exporter- (time to export) and importer-specific (most-favored tariff) non-discriminatory trade policy variable within a panel data structural gravity model. However, the approach in our paper differs from theirs, in that we employ different empirical measures of time and additional control for differential trends in international trade. Methodologically, we apply a different estimator that does not suffer from the incidental parameter problem. Furthermore, our paper extends the analysis with counterfactual simulations of two scenarios on the welfare and trade effects of reductions in time spent on border procedures accounting for uncertainty in the estimates. Finally, we introduce a way of using ad valorem tariff equivalents to measure the effect sizes of trade facilitation efforts that takes into account the full endowment general equilibrium impact.

Our panel data sets with domestic flows allows us to control for heterogeneity with the exporter-time and importer-time constraints, directional dyadic fixed effects (as suggested by Baier & Bergstrand, 2007), and flexible time trends for cross-border flows. Hence, our estimates are not contaminated by country-time specific unobservables that influence both domestic and border-crossing trade flows, such as the institutional environment or inland infrastructure, nor do they pick up pairwise time-invariant factors or the increasing importance of international trade (see Yotov, 2012). As we argue that the potential sources of endogeneity are projected out due to the structure of our estimator (see in Appendix B), we claim a causal interpretation of the resulting estimates. To increase the focus on border crossing procedures, we obtained data on the specific components of time to export and import from the World Bank Group. The four components are the time needed for preparing import and export documents, inland transit transport from factory gate to the next port, terminal handling and customs inspection. Of those four components, the time needed for inland transportation may also affect domestic trade flows so we disregard this component for further analysis. The models are estimated on the time spent on total border procedures and on the most important component - the time needed to prepare the necessary documents for exporting and importing - to identify the effect of border-crossing procedures on trade.

Table 1: Literature on the impacts of time on trade

Study	Method	Sample	Time measure	Time (semi)-elasticities	AV-TE
Persson (2008)	cross-section gravity model, PPML, Heckman, and IV (number of documents)	122 countries / aggregate / 2005	WB-DB, time to export and import	one day increase in export (import) time decreases exports by 1 (0.5) percent at sample mean	-
Martínez-Zarzoso & Márquez-Ramos (2008)	cross-section gravity model, PPML	13 exporters and 167 importers / product groups / 2000	WB-DB, time to export and import	one day increase in export (import) time decreases exports by 0.22 (0.83) percent at the sample mean	-
Djankov et al. (2010)	Single-difference gravity equation, OLS and IV (time to export of neighbors of landlocked countries, number procedures to start a business)	146 countries / aggregate and product groups / 2005	WB-DB, time to export	one additional day reduces trade by 1.3 percent	-
Freund & Rocha (2011)	cross-section gravity model, OLS, IV (time of neighbors of landlocked countries), trade in new products	multi-country / aggregate / 2005	WB-DB, time to export (inland transit time, customs and port time, and documents time)	one percent increase in export inland travel times decreases exports by 7 percent	2
Bourdet & Persson (2012)	panel gravity model, PPML	EU27 / product groups / 2006-2008	WB-DB, time to import	one percent increase in time to import decreases trade by 0.44 percent	-
Hummels & Schaur (2013)	panel Air/Ocean difference revenue equation	US ocean and airport shipment data / product groups / 1991-2005	Port to port transit time	increasing ocean transit time by one day reduces imports (relative to air) by 0.9 percent	0.6 - 2.1
Zaki (2014)	ratio-type cross-section gravity model /IV (number of documents, procedures to start a business and others)	GTAP 7 / product groups / 2004	WB-DB, time to export and import	one percent increase in time to import (export) decreases trade by 1.2 (0.7) percent	0.4 - 0.9
Carballo et al. (2016)	cross-section gravity model, OLS and IV (other ships arriving at port, randomly assigned customs inspection)	Firm-level data Peru / product groups / 2011	time between clearance date of shipment at customs and unloading of vessel	one additional day of border delay decreases firms imports by 0.4 percent	0.7 - 1.6
Ansón et al. (2017)	cross-section structural gravity, PPML	multi-country / aggregate / 2013	United Postal Union delivery times: median of delivery time between country pairs	one percent increase in median time decreases trade by 0.07 percent	-
Heid et al. (2017)	panel structural gravity model, PPML	68 countries / aggregate / 2005-2012	WB-DB, time to export (in levels)	one additional day of time to export reduces trade flows by 3.5 percent	-

Notes: AT-TE ... Ad valorem tariff equivalent in percentage points; WD-DB ... World Bank Doing Business.

3 Empirical Model

As an empirical model we employ an econometrically estimated structural gravity model in the spirit of Anderson & van Wincoop (2003). The panel data structure enables us to control for unobserved importer-time, exporter-time and directional importer-exporter effects. As our sample covers the years 2006 to 2012 we can allow for equilibrium adjustments in trade flows by using three 3-year intervals. Since our dataset includes domestic flows we are able to identify non-discriminator trade policy variables. Our econometric estimator, the CPPML, is based on a generalized linear model which has desirable properties regarding zero-flow observations and heteroscedasticity, as outlined for the PPML in Santos Silva & Tenreyro (2006). Thus, our model and estimator incorporate all recommendations for empirical structural gravity model estimation outlined in Piermartini & Yotov (2016).

3.1 Empirical Specification

The empirical specification of our our gravity model reads as:

$$
\begin{aligned}
s_{ijt} \;=\;& \exp\left(\delta B_{ij} * TT_{ijt} + \tau B_{ij} * (1 - CU_{ijt}) * \ln(1 + MFN_{jt})\right) \\
& * \exp\left(\sum_{k=0}^{T-2} \alpha_{1,1+k} B_{ij} * \mathbb{1}[t = k+2] + \sum_{k=0}^{T-2} \alpha_{2,1+k} B_{ij} * \mathbb{1}[t = k+2] * CB_{ij}\right) \\
& * \exp\left(\sum_{k=0}^{T-2} \alpha_{3,1+k} B_{ij} * \mathbb{1}[t = k+2] * \ln DIST_{ij} + \alpha_4 B_{ij} * RTA_{ijt-1}\right) \\
& * \exp\left(\beta_{it} + \gamma_{jt} + \mu_{ij}\right) + \epsilon_{ijt}.
\end{aligned} \tag{1}
$$

The dependent variable measures the trade flows X_{ijt} between exporter $i = 1, ..., C$, importer $j = 1, ..., C$ at period t normalized by world production $Y_{t,W}$, i.e. $s_{ijt} = X_{ijt}/Y_{t,W}$ such that $\sum_{i=1}^{C}\sum_{j=1}^{C} s_{ijt} = 1$. Note that domestic trade flows are included (i.e. $i = j$) and intervals of three years are chosen to allow for adjustments in trade flows to a new equilibrium following a change in trade costs (see Trefler, 2004), Therefore, $t = 1$ for 2006, $t = 2$ for 2009 and $t = 3$ for 2012.

As a measure of time we include the geometric mean ($TT_{ijt} = 0.5 * \ln(TE_{it} * TI_{jt})$) of time to export ($TE_{it}$) and time to import ($TI_{jt}$), interacted with a dummy variable B_{ij} indicating international trade flows ($i \neq j$) with one and zero otherwise.This measure of time is different from the preceding literature. Other empirical studies (for example Heid et al., 2017) used the log or level of either the time to export or the time to import, or both as separate measures in their specifications. Note that our functional form of time corresponds to

$$\delta B_{ij} * TT_{ijt} = \delta_{EXPORTER} * 0.5 * \ln(TE_{it}) * B_{ijt} + \delta_{IMPORTER} * 0.5 * \ln(TI_{jt}) * B_{ijt}$$

with $\delta = \delta_{EXPORTER} = \delta_{IMPORTER}$. Hence, we restrict the effect of time to be the same irrespective of whether it is due to exporter-country and importer-country border-crossing procedures to be carried out. This restriction can be justified on theoretical grounds, arguing that an additional day (or percent when using logs) in time should impose the same additional costs for cross-border trade, regardless whether faced by the exporting or importing country. Moreover, the choice of the functional form is motivated by identification and endogeneity concerns of the time variables used that represent non-discriminatory trade policy variables. Building upon the proof by contradiction in Heid et al. (2017), we demonstrate in Appendix A that if $TE_{ct} = TI_{ct}$ for countries $c = 1, ..., C$, the parameters on the time to export and time to import are not jointly identified. As the data on time to import is highly correlated with the data on time export, this problem can be avoided by imposing this functional form restriction. In Appendix B we further show that using this functional form is also robust to endogeneity stemming from country-period specific sources. Employing this functional form, the interaction with B_{ijt} ensures identification and that the effects of border crossing procedures are restricted to affect border crossing trade flows only. The logarithmic transformation captures potential non-linearities in the effects and enables the interpretation of the coefficient as an elasticity in exponential models.

The simple average of the most-favored nation tariff is included as $\ln(1 + MFN_{jt})$ and interacted with B_{ij} and $1 - CU_{ijt}$, where CU_{ijt} is a dummy variable indicating whether country i and j are in a customs union at time t. As with the measure on time spent on border-crossing procedures, the interaction with B_{ij} identifies the parameter τ in a structural gravity framework with either exporter-time, importer-time dummy variables or the according restrictions in CPPML framework applied here (Pfaffermayr, 2017). We further interact this measure with $1-CU_{ijt}$ which sets the tariff rate between countries within a customs unions to zero.[4] Note that the variable resulting from this interaction is no longer a non-discriminatory trade policy variable, since it discriminates between domestic and international, and flows inside and outside currency unions. The estimate of τ represents the coefficient of a direct price shifter and can thus be interpreted as a trade elasticity or elasticity of substitution, depending on the underlying theoretical model. We will exploit the estimate on this parameter and its uncertainty for the counterfactual simulations rather than using a fixed parameter value from the literature.

As additional controls we include a series of border effects and a dummy variable indicating that trade between country i and j is subject to a regional trade agreement (RTA_{ijt-1}), lagged one period (i.e. 3 years) to allow for fading in effects. The specification includes a border effect for each time period included except for the first (which is the base effect), as an interaction of the border crossing trade dummy variable B_{ij} and the indicator function $\mathbb{1}[.]$ selecting the respective period among $t = 1, \ldots, T$. These effects are allowed to vary between trading partners that are contiguous, indicated by the common border dummy variable CB_{ij}, and by distance with $\ln DIST_{ij}$ being the natural logarithm of population-weighted distance between countries i and j. Note that the base effect for border-crossing trade for period $t = 1$ is given by the linear combination of the respective fixed effects or constraints given in the last line in Equation (1), with β_{it} being the outward and γ_{jt} the inward multilateral resistance terms (i.e. the structural part).

Finally, time-invariant directional dyadic fixed effects are given by μ_{ij}. Note that the effects of our time measure are identified over time since their level is absorbed by these directional country-pair effects. Inclusion of these effects has been argued as a means to account for endogeneity of regional trade agreements (see Baier & Bergstrand, 2007). In the present context, we argue that these effects absorb trade facilitation efforts due to stronger historical trade ties between any two countries.

3.2 Estimation Method

We estimate Equation (1) via Constrained Poisson Pseudo-Maximum Likelihood (CPPML) developed in Pfaffermayr (2017) and recently applied in Oberhofer & Pfaffermayr (2017) for the estimation of the trade and welfare effects of Brexit. Compared to the established dummy variable PPML estimator, the CPPML has three advantages: 1) it allows to obtain confidence bands for the counterfactual predictions, 2) these predictions are always theory-consistent (obey restrictions) even with data missing at random, and 3) the variances on the structural parameters are not asymptotically downward biased, i.e. the CPPML is not affected by the incidental parameter problem. As in Oberhofer & Pfaffermayr (2017) a zig-zag algorithm is implemented to partial out the bilateral fixed effects. The CPPML also enables three-way clustering of standard errors by exporter-time, importer-time and exporter-importer.

Estimated parameters are exploited for comparative static analysis via counterfactual simulations. In particular, we are interested in the conditional general equilibrium effects at fixed consumption and expenditure shares (see Larch & Yotov, 2016) as outlined in Pfaffermayr (2017). As the multilateral resistance terms are a function of the parameters, the delta method can be employed to derive standard errors and confident intervals on the point estimates of the counterfactual predictions. Similar to Oberhofer & Pfaffermayr (2017) we simulate the effects of changes in our trade policy measure of interest on domestic and international trade flows and calculate welfare effects according to Costinot & Rodriguez-Clare (2014). Furthermore, since we obtain an estimate on the effect of a change in tariffs, we can compute an estimate and confidence intervals for the percentage point change in the tariff equivalent stemming from the counterfactual trade policy scenarios.

[4] One could also argue that it is very unlikely that the average MFN tariff rate would apply to countries that signed a regional trade agreement (RTA). However, while RTA's aim towards gradual reductions in bilateral tariff rates, those rates need not necessarily drop to zero immediately.

3.3 Data

The data on trade flows we use in this paper is taken from Oberhofer & Pfaffermayr (2017) and is based on OECD's STAN, Nicita & Olarreaga (2007) and data on aggregate goods trade including domestic trade flows (i.e. $i = j$). The data used to construct the database (gross production, total exports and imports) are taken from OECD-STAN, UNIDO's INDSTAT database, CEPII and WIOD. The analysis of this paper based on the three periods 2006 (t=1), 2009 (t=2) and 2012 (t=3) of that dataset, covering 63 countries. Several consistency checks have been applied to the data and a few missing values have been interpolated (see Oberhofer & Pfaffermayr, 2017, for details). Population weighted distances and contiguity are obtained from the CEPII gravity database Mayer & Zignago (2011). As most-favored nation tariff rate we take the simple average of the applied tariff rate over all products obtained from UNCTAD's Trade Analysis Information System (TRAINS) accessed via World Integrated Trade Solution (WITS). We cross-checked that data with the WTO Tariff Reports, and utilize the most plausible value.[5] Additionally, a few missing values[6] have been interpolated. Data on Regional trade agreements is taken from Mario Larch's Regional Trade Agreements Database (see Egger & Larch, 2008).

Data on time to export and imports is taken from the World Bank's Doing Business indicators on trading across borders (see Djankov et al., 2010), accessed via World Bank Database. Starting with 2006, data is recorded yearly but on a country-specific basis, i.e. for each year there are no bilaterally varying time measures between country pairs available, but just two summary measures, one for the mean time to export from (TE_c) and one for the mean time to import (TI_c) to the country $c = 1, ..., C$ in question. The time to export differs from the time to import, but the two measures are highly correlated ($r = 0.96$).

Total export (import) time consist of the four components 1) documents preparation, 2) customs clearance and inspections, 3) port and terminal handling and 4) inland transportation (from warehouse to next sea port or vice versa) and handling. A procedure starts with the time the firm begins preparing the necessary documents and stops the time the cargo reaches the clients warehouse. International ocean transit time is not counted. If the destination is a landlocked country, the time for inland transport also includes transit time.

The information is provided by local freight forwarders, shipping lines, customs brokers and port officials, via a case study. Within this case study it is assumed that the company is a domestically owned, formally registered private, limited liability company with 100 or more employees, is located in the countrys most populous city and exports more than 10% of its sales to international markets. The good travels in a dry-cargo, 20-foot, full container load, is not hazardous nor does it require any special phytosanitary or environmental safety standards. In particular, the Standard International Trade Classification (SITC) Revision 3 categories SITC 65: textile yarn, fabrics, made-up articles, SITC 84: articles of apparel and clothing accessories and SITC 07: coffee, tea, cocoa, spices and manufactures thereof, are considered by the respondents.

In the year 2016 (for data on 2015) the methodology of the trading across borders indicators has been extensively revised. In the new import case study, a standardized shipment of 15 metric tons of containerized auto parts (HS 8708) from the economy from which the largest value (price times quantity) of auto parts is imported, is assumed. The export case study assumes that the product in which the country has a comparative advantage is shipped to the export partner that is the largest purchaser of this product. Since our dataset covers the periods 2006-2012, we apply the measure according to the old methodology. It is argued (see Hillberry & Zhang, 2017) that the new methodology eliminated some potential problems, such as the long delay times for landlocked countries. Since the transit time to ports is recorded in the old methodology, we believe that the measures up to 2012 contain valuable information on procedures that may influence global trade potentials, especially since nearly 80 (70) percent of globally traded volumes (values) are carried via maritime transport (see UNCTAD, 2017) and thus access to ports is essential.

The data that can be accessed via the World Bank contains the sum of the four components for each country from the perspective of either the importer or exporter. Since this aggregate includes the time of inland transportation, part of the days recorded might affect not only border crossing but also domestic trade. We therefore requested

[5] For example, Switzerland is reported to have a most-favored nation tariff of zero for all products according to the TRAINS database. However, the WTO Tariff Report show a positive value for the simple average of the MFN tariff.

[6] Russia (2006), China (2012), Turkey (2012), Peru (2012) and Kazakhstan (2006, 2009).

and gratefully received the individual data on the four components from the World Bank Group.[7] Table 2 shows the mean days of the World Bank's time to export and time import by income group and in the functional form used in our empirical analysis. We define a country as 'High' if that country was classified as high income country according to the World Bank definition in our base year 2006. The remaining lower, lower-middle and upper-middle income countries are summarized under 'Middle/Low'. Further we define $TT^{TOTAL} = TT^{BORDER} + TT^{INLAND}$ and $TT^{BORDER} = TT^{DOCUMENTS} + TT^{TERMINAL} + TT^{CUSTOMS}$, whereas we do not report the time for inland transportation from factory gate to the next port TT^{INLAND}, since it also affects domestic trade.

Table 2: Average days to export and import by income group and years

	exporter - importer	2006	2009	2012
TT^{TOTAL}	Middle/Low - Middle/Low	23.9	20.5	18.8
	Middle/Low - High	15.0	13.8	12.7
	High - Middle/Low	16.3	15.0	14.0
	High - High	10.0	9.9	9.3
TT^{BORDER}	Middle/Low - Middle/Low	19.4	16.6	14.9
	Middle/Low - High	11.9	10.8	9.8
	High - Middle/Low	13.3	12.1	11.2
	High - High	8.1	7.8	7.3
$TT^{DOCUMENTS}$	Middle/Low - Middle/Low	12.6	10.5	9.3
	Middle/Low - High	7.5	6.6	5.9
	High - Middle/Low	8.3	7.5	6.7
	High - High	4.9	4.6	4.3
$TT^{TERMINAL}$	Middle/Low - Middle/Low	3.4	3.2	3.0
	Middle/Low - High	2.3	2.3	2.2
	High - Middle/Low	2.7	2.6	2.5
	High - High	1.8	1.9	1.9
$TT^{CUSTOMS}$	Middle/Low - Middle/Low	3.0	2.6	2.3
	Middle/Low - High	1.9	1.7	1.5
	High - Middle/Low	2.0	1.9	1.7
	High - High	1.2	1.2	1.1

Source: World Bank Group, own calculations.
Note: Table contains average over $\exp(0.5 * \ln(TE_{it} * TI_{jt}))$.

For each of the four exporter-importer pairs, the mean days spent on preparing documents is by far the largest component, accounting for about half of the total time. On average, the least time intensive border crossing procedure is customs inspection. The average numbers of days spent on each procedure are highest for trade between middle/low income countries and lowest for trade between high income countries. The difference in the average days of export from middle/low to high and export from high to middle/low income countries is due to asymmetric time requirements for imports and exports. The mean time spent on each of the components steadily declines over time, indicating ongoing trade facilitation efforts. In absolute terms, the largest declines occurred in the number of days required for preparation of documents. For trade between middle/low income countries the time required reduced by 2.3 days on average. Descriptive statistics on the variables used and the correlation of their triple-demeaned (exporter-time, importer-time, exporter-importer) values are shown in Appendix C. The particularly strong correlation between the total and border time is driven to a large extent via the component preparations of documents.

[7] We like to thank Marilyne Youbi from the Doing Business Unit of the World Bank Group for providing the data and Allen Dennis for contact details.

4 Empirical Analysis

4.1 Estimation Results

Table 3 summarizes the results of the CPPML estimations for four different specifications of Equation (1). Results on structural parameters and the directional country-pair fixed effects are not reported but available upon request. Column (1) shows the parameter estimates and corresponding t-values with time measured as a total of all four components. The estimate on time is statistically significant on conventional levels with a value of -0.31, i.e. a one percent increase in the average time to trade between to countries decreases the bilateral trade flow by 0.31 percent.

Table 3: Parameter estimates from panel data CPPML

	(1)			(2)			(3)			(4)		
	coef.	t-val.		coef.	t-val.		coef.	t-val.		coef.	t-val.	
$B * \ln(TT^{TOTAL})$	-0.31	-2.71	***									
$B * \ln(TT^{BORDER})$				-0.37	-2.92	***						
$B * \ln(TT^{DOCUMENTS})$							-0.19	-2.11	**	-0.24	-2.67	**
$B * \ln(TT^{TERMINAL})$							-0.17	-1.12				
$B * \ln(TT^{CUSTOMS})$							-0.11	-1.07				
$B * \ln(1 + MFN) * (1 - CU)$	-5.78	-2.18	**	-5.67	-2.21	**	-5.45	-2.13	**	-6.03	-2.30	**
$B * \mathbb{1}[t := 2009]$	0.13	1.26		0.13	1.20		0.14	1.33		0.12	1.06	
$B * \mathbb{1}[t := 2012]$	0.13	0.92		0.11	0.72		0.11	0.77		0.10	0.71	
$B * \mathbb{1}[t := 2009] * CB$	-0.03	-0.80		-0.03	-0.76		-0.03	-0.71		-0.03	-0.83	
$B * \mathbb{1}[t := 2012] * CB$	-0.16	-2.78	***	-0.16	-2.83	***	-0.16	-2.87	***	-0.16	-2.85	***
$B * \mathbb{1}[t := 2009] * \ln(DIST)$	-0.02	-1.61		-0.02	-1.63		-0.03	-1.82	*	-0.02	-1.46	
$B * \mathbb{1}[t := 2012] * \ln(DIST)$	0.03	1.39		0.03	1.44		0.03	1.47		0.03	1.47	
$B * RTA_{t-1}$	0.04	1.29		0.04	1.30		0.04	1.18		0.05	1.44	

Notes: The panel comprises 3 periods of 3-year intervals and 63 countries with 131 out of the total of 11,826 trade flows being missing. Standard errors are clustered over country-pairs, importer-years and exporter-years. *,** ,***... Significant at 10%-, 5%- and 1%-level.

As the total time to trade includes the time for inland transportation, that may also affect domestic trade flows, Column (2) reports the results of a specification including only the time required for border-crossing procedures. Disregarding the inland transportation time component amplifies the effect of time to -0.37 and increases precision. In the third specification we decompose the time spent on border procedures into the three components: document preparation, customs clearance and inspections and port and terminal handling. All parameters show the expected negative sign, but only the parameter on the time required for document preparation is estimated precisely. Therefore in Column (4) we only included the time for document preparation in our fourth specification. The parameter is precisely estimated at -0.24, i.e. the elasticity is smaller in absolute terms than the elasticity on total border procedures. Since the documents time seems to drive the border procedures effects, Specification (4) constitutes our preferred model.

Regarding the other parameters common to all specifications, the coefficient on the most-favored nation tariff is negative and statistically significant in all specifications, ranging in a magnitude between -6 to -5.5. Our estimates are very similar to mean and median values reported for tariffs in structural gravity models in Head & Mayer (2014) of -6.7 and -5 and the range of -3.4 to -9.9 with a cross-country average of -5.9 reported in Imbs & Mejean (2017). In 2012 contiguous countries traded on average 17 percent less than countries in 2006 (base effect).[8] The coefficient on regional trade agreements is small and statistically insignificant in all specifications. As directional fixed effects

[8]This effect was calculated using the formula of Garderen & Shah (2002), i.e. $100 * (EXP(\alpha_{22} - 0.5 * \sigma_{\alpha_{22}}) - 1)$.

are included in all specifications, the effect of trade agreements is only identified by country-pairs that either form or dissolve a RTA over the sample period. Since there is not much variation in RTA_{t-1} between 2006 and 2012 there seems to be not enough information in the data that can be exploited for identification.

Before we compare our results to the empirical literature, we address potential endogeneity concerns regarding the presented results. Djankov et al. (2010) raised the issues of reverse causality and simultaneity of border time with respect to trade flows. First, countries historically maintaining stronger trade relationships are likely to have invested more heavily in trade facilitating measures and thus account for shorter border delays. The resulting parameter estimate should be biased downwards, implying a stronger negative effect of time on trade. Second, higher trade volumes may lead to congestion effects in infrastructure or institutions, thus increasing the reported time for those procedures in the survey data. This issue should lead to an upward bias in the estimate.

The first issue is similar to the endogeneity concerns of regional trade agreements. Following the approach in Baier & Bergstrand (2007), the inclusion of country-pair fixed effects has become a common empirical practice to tackle this concern. As all of our specifications include these time-invariant country-pair effects, identification is achieved from within changes in time of border procedures and not based on levels. Hence, we believe that our model solves the first concern. The second issue reflects the way the indicators on time are measured, in particular that the survey respondents may also report congestion effects that are driven by increasing trade performance. To the extent that such effects are driven by components common to exporter-time and importer-time specific shocks, we outlined in Appendix B that endogenous effects of this structure are projected out in our model and thus we should obtain consistent parameter estimates. We thus causally interpret the coefficients on our time measures, but particularly for the specifications (2) to (4) since these do not include the inland transportation component.

Our estimates on the direct effect of time on trade flows are at the lower end of the values found in the empirical literature. As a comparison to the results obtained in the empirical literature we consider the elasticity of border time with -0.37, which is of a comparable magnitude to -0.44 found in Bourdet & Persson (2012) and -0.7 found in Zaki (2014).[9] To compare our estimates to the empirical estimates on the direct effect of an additional day, we translate the elasticity to a day-equivalent at the sample mean. At a mean of 12.4 days needed to comply with border procedures, increasing the border delays by an additional day corresponds to roughly 8 percent, resulting in a decrease of trade flows of 3 percent ($=-0.37*8$). This estimate is located on the upper end of values found in the empirical literature. Most of the reported values range between -0.2 and -1.3 (see Table 2), with the exception of Heid et al. (2017) who estimated the effect of time to export at -3.5.[10] Using our estimate of the most-favored nation tariff of -5.67 in Column (2), the ad valorem tariff-equivalent of one day of border procedures amounts to 0.82 [95% confidence bands: 0.002; 1.64] percentage points on average. This figure was calculated by simulating a counterfactual scenario in which the border time in 2012 is reduced by one day relative 2012 and calculating the average (over all country pairs) tariff equivalent based on the direct trade effects according to Appendix E. With values from the literature ranging from 0.4 to 2.1, our estimate is situated in the lower spectrum.

To check the robustness of the results, Appendix D includes two Tables summarizing the results for alternative functional forms. Table 10 includes the logarithm of the sum of the exporter and importer component, $TT_{ijt} = B_{ijt} * \ln(TE_{it} + TI_{jt})$, and Table 11 contains the log of only the time to export, $TT_{ijt} = B_{ijt} * \ln(TE_{it})$. Overall the results are very similar: The parameters retain their signs, statistical significance and remain at comparable magnitudes. However, Specification (3) in Table 11 seems to indicate that when focusing on time to export only, the negative impact of border delays are driven by port and terminal handling rather than documents preparation.

[9]Our estimate is not directly comparable with the estimate of -7 in Freund & Rocha (2011), since their estimate specifically relates to inland transportation time, i.e. the component that we specifically excluded from the analysis.

[10]Note that Heid et al. (2017) included the time to export in levels in their structural gravity PPML model and interpreted the resulting parameter as a semi-elasticity. However, to evaluate the effect of level variables in exponential models, an evaluation at the conditional mean would be required.

4.2 Trade and Welfare Effects

The parameter estimates of our structural model in Table 3 allow us to calculate counterfactual full endowment general equilibrium trade and welfare effects based on alternative numbers of days spent on border-crossing procedures along the lines suggested by Yotov, Piermartini, Monteiro & Larch (2016).[11] In contrast to the direct effects on trade flows discussed before, the full endowment effects take into account the changes on relative trade costs, factory gate prices and production. In addition to the effects on trade and welfare, we also derive an estimate on the ad valorem tariff equivalent of the changes in time as a measure of effect size that relates to the direct impact on international trade flows. The derivation of these ad valorem tariff equivalents is outlined in Appendix E.

The resulting effects on international trade and ad valorem equivalents are presented as unweighted averages of groups containing bilateral trade combinations and the effects on domestic trade and welfare as unweighted averages within income country groups. The grouping is chosen with respect to findings from the literature and the data sample available. Empirical studies such as Persson (2008) and Freund & Rocha (2011) investigate the impacts of trade facilitation with special attention to developing countries and found larger impacts and large potential for improvement for those countries. We therefore grouped the countries in our sample by development status approximated by the income groups classification of the World Bank. To ensure an approximately equal number of countries in each group, we split the sample into (a) high income countries and (b) lower/middle income countries. As can be seen from Table 2 there are large differences in the time needed to comply with border procedures between those two country groups.

We chose the structural parameters of Specification (4) of Table 3 for the counterfactual analysis, since the time for the preparation of documents accounts for the main source of variation in the data. Alternatively, results for the counterfactuals using the total border-crossing time reported in Specification (2) of Table 3 are presented in Appendix F.

Scenario 1 simulates the full endowment general equilibrium effects of the changes in the time to prepare documents between 2006 and 2012. This scenario therefore illustrates the total magnitude of trade facilitation efforts in document preparation that historically took place in our sample. The effects of this scenario are expressed in percent changes (i.e. percentage points for the ad valorem tariff equivalents) in trade volumes stemming from trade facilitation efforts. For the unobserved counterfactual we apply the time observed documents preparation time from 2006 for the year 2012. Scenario 2 sets our measure of time of bilateral trade combinations involving low/middle income countries in 2012 to the mean 2012 value of combinations involving just high income countries. Percentage (and percentage point) changes are expressed as difference of the newly set 2012 to the observed 2012 values with observed 2012 values as base. In our third scenario, we simulate the effects of a full trade facilitation to the levels of the best performing country-pair in 2012, i.e. the international best practice scenario of our sample. As in Scenario 2, the percent and percentage changes are calculated with respect to the observed 2012 values as a base. In contrast to Scenario 1 that showed the historic effects, Scenarios 2 and 3 quantify potential gains for further trade facilitation efforts of low/middle income and all countries respectively. The corresponding changes in the mean number of days spent on the preparation of documents (Specification 4) is shown in Table 4.

Table 5 summarizes the direct effects on international trade flows and the ad valorem tariff equivalents of Scenario 1 in the upper, Scenario 2 in the middle and Scenario 3 in its lower panels, respectively. The historic improvements (Scenario 1) in trade facilitation had the largest impacts on trade between low/middle income countries and exports from low/middle income countries to high income countries, with growth rates of 7.8 [95% Confidence bounds 1.9; 13.7] and 5.7 [1.4; 9.9] percent, respectively. However, as the 95%-confidence bands indicate, the effects are not very precisely estimated. The exports from high to low/middle income countries and the trade between high income countries grew on average by 5.2 [1.3; 9] and 3.2 [0.8; 5.5] percent between 2006 and 2012 due to decreases in time needed for document preparation. The corresponding ad valorem tariff equivalents that are attached to the changes in cross-border procedures time range between -1.3 [-2.6; -0.04] for trade between low/middle and -0.5 [-1.04; -0.02] percentage points for trade between high income countries.

The second scenario in the middle panel, shows the potential gains from a reduction in time to prepare documents

[11] For a complete derivation of the full endowment general equilibrium effects and their standard errors using the CPPML see Pfaffermayr (2017).

Table 4: Scenario descriptions, change in mean time to trade of Specification (4)

	Baseline	Counterfactual	Difference
Scenario 1: $TT^{DOCUMENTS}$ at 2006 levels			
Middle/Low - Middle/Low	12.7	9.3	-3.4
Middle/Low - High	7.5	5.9	-1.6
High - Middle/Low	8.3	6.7	-1.6
High - High	4.9	4.2	-0.6
Scenario 2: Mean $TT^{DOCUMENTS}$ High-High in 2012			
Middle/Low - Middle/Low	9.3	4.0	-5.3
Middle/Low - High	5.9	3.9	-2.0
High - Middle/Low	6.7	4.0	-2.8
High - High	4.2	4.2	0.0
Scenario 3: Min $TT^{DOCUMENTS}$ in 2012			
Middle/Low - Middle/Low	9.3	2.0	-7.3
Middle/Low - High	5.9	2.0	-3.9
High - Middle/Low	6.7	2.0	-4.7
High - High	4.2	2.0	-2.2

Note: Table contains group means of $\exp(0.5 * \ln(TE_{it} * TI_{jt}))$

Table 5: Direct effects on international trade with corresponding tariff equivalent, Specification (4)

	International Trade			Tariff Equivalent		
	%-change	CI-lower	CI-upper	pp-change	CI-lower	CI-upper
Scenario 1: $TT^{DOCUMENTS}$ at 2006 levels						
Middle/Low - Middle/Low	7.77	1.85	13.68	-1.32	-2.60	-0.04
Middle/Low - High	5.67	1.39	9.94	-0.95	-1.86	-0.03
High - Middle/Low	5.15	1.28	9.03	-0.89	-1.75	-0.03
High - High	3.16	0.80	5.51	-0.53	-1.04	-0.02
Scenario 2: Mean $TT_{DOCUMENTS}$ High-High in 2012						
Middle/Low - Middle/Low	20.07	3.95	36.18	-3.21	-6.28	-0.13
Middle/Low - High	8.72	2.05	15.39	-1.43	-2.81	-0.05
High - Middle/Low	11.68	2.63	20.74	-1.95	-3.82	-0.07
High - High	0	0	0	0	0	0
Scenario 3: Min $TT_{DOCUMENTS}$ in 2012						
Middle/Low - Middle/Low	41.59	5.46	77.71	-6.01	-11.70	-0.32
Middle/Low - High	27.35	4.76	49.94	-4.08	-7.97	-0.19
High - Middle/Low	31.29	5.06	57.52	-4.73	-9.23	-0.23
High - High	17.94	3.66	32.22	-2.77	-5.43	-0.11

Notes: Two-sided 95%-confidence intervals are calculated using the delta method. pp ... percentage point.

of low/middle income countries to the mean levels of high income countries in 2012. Trade between middle/low income countries could be increased by 20 [4; 36.2] percent, again estimated less precisely but statistically significant at conventional levels. Furthermore, the results show a significant increase of 8.7 [2.1; 15.4] percent of exports from middle/low to high and 10 percent from high to middle/low income countries. In this scenario, the ad valorem tariff equivalent for trade between low/middle countries amounts to -3.2 [-6.3; -0.1] percentage points, emphasizing the potential of further trade facilitation efforts. Note that the direct effects on international trade and their tariff equivalents are zero for trade between high income countries, since their mean levels are taken as counterfactual for this scenario and thus remain unaffected for trade between high income countries in this scenario. The results of the best practice scenario in the lower panel consequently indicate the highest direct trade and thus tariff equivalent effects among all scenarios. Direct trade effects between middle/low income countries reach over 42 [5.5; 77.7] percent with an ad valorem tariff equivalent of -6 [-11.7; -0.3].

The full endowment general equilibrium effects on international trade flows are outlined in Table 6. Taking into account adjustments in prices and incomes, the effects of time on trade reduces to between 1.7 [0; 3.3] for exports from high to middle/low and 4.4 [-0.03; 8.9] percent for exports from middle/low to high income countries in the first scenario. Again the confidence bands are very broad, with only the effect on trade between high income countries being statistically significant. Scenario 2 results in much larger effects for trade involving middle/low income countries ranging between 8.4 [-0.4; 17.1] and 11.6 [0.9; 22.2] percent. Note that due to trade diversion effects, trade between high income countries would decrease by 1.9 [0.8; 2.9] percent in the new equilibrium. Reducing the time for documents preparation to the best practice level in 2012 could potentially increase trade between middle/low income countries by 20 percent [1.3; 38]. In this scenario, trade between high income countries would also increase by 5.6 percent [0.8; 10.4].

Table 6: Full endowment general equilibrium effects on international trade, Specification (4)

	%-change	CI-lower	CI-upper
Scenario 1: $TT^{DOCUMENTS}$ at 2006 levels			
Middle/Low - Middle/Low	4.02	-0.55	8.59
Middle/Low - High	4.44	-0.03	8.91
High - Middle/Low	1.65	0.00	3.29
High - High	2.15	0.58	3.72
Scenario 2: Mean $TT_{DOCUMENTS}$ High-High in 2012			
Middle/Low - Middle/Low	11.59	0.93	22.24
Middle/Low - High	8.35	-0.43	17.14
High - Middle/Low	2.43	0.77	4.08
High - High	-1.88	-2.92	-0.84
Scenario 3: Min $TT_{DOCUMENTS}$ in 2012			
Middle/Low - Middle/Low	19.66	1.31	38.02
Middle/Low - High	17.58	-0.04	35.19
High - Middle/Low	7.68	2.19	13.18
High - High	5.62	0.79	10.44

Note: Two-sided 95%-confidence intervals are calculated using the delta method.

The corresponding domestic trade and welfare effects are shown in Table 7. In general, the uncertainty on the estimates is substantially smaller compared to the estimates on international trade and tariff equivalents. As a result, all estimates are statistically significant at a 5%-level. Mirroring the effects of the international trade flows above, the improvements in time between 2006 and 2012 resulted in welfare gains of 0.7 [0.4; 1] percent for low/middle income countries and 0.2 [0.03; 0.4] percent for high income countries, on average. Potential future welfare gains in Scenario 2 are estimated to vary around 1.5 [0.5; 2.6] for low/middle and 0.4 [0.2; 0.6] percent for high income countries. Note that even though trade between high income countries decreased in this scenario, the average welfare effect is positive and significant, due to the trade effects between low/middle and high income countries. In the best practice scenario, welfare in middle/low income countries could on average increase by 3.5 [1; 6.1] percent and for high income countries by 2.2 [0.6; 3.9] percent.

Table 7: Full endowment general equilibrium effects on domestic trade and welfare, Specification (4)

	Domestic Trade			Welfare		
Income Group	%-change	CI-lower	CI-upper	%-change	CI-lower	CI-upper
			Scenario 1: $TT^{DOCUMENTS}$ at 2006 levels			
Middle/Low	-3.63	-5.02	-2.23	0.74	0.42	1.05
High	-1.01	-1.85	-0.17	0.20	0.03	0.38
			Scenario 2: Mean $TT_{DOCUMENTS}$ High-High in 2012			
Middle/Low	-7.38	-11.86	-2.89	1.54	0.50	2.57
High	-1.89	-2.93	-0.84	0.38	0.15	0.61
			Scenario 3: Min $TT_{DOCUMENTS}$ in 2012			
Middle/Low	-16.00	-26.00	-5.99	3.53	0.95	6.10
High	-10.53	-17.55	-3.51	2.24	0.56	3.91

Note: Two-sided 95%-confidence intervals are calculated using the delta method.

5 Summary and Concluding Remarks

This paper assessed the impacts of reductions in time spent on border procedures on international trade and welfare for a sample of high and middle/low income countries between 2006 and 2012. We employed a theory-consistent panel data structural gravity model augmented by non-discriminatory trade policy variables on tariffs and time for exports and import. The model accounts for potential endogeneity of time spent on border procedures by controlling for a rich set of unobserved effects which allows to project out any exporter-time or importer-time source for endogeneity. The estimates of the econometric model are used to simulate full endowment general equilibrium effects of past efforts and future potentials for trade facilitation measures. The econometric estimator used overcomes the incidental parameter problem, allows for three-way clustering of the standard errors and permits the calculation of standard errors on the counterfactual general equilibrium impacts.

We find an ad valorem tariff equivalent of a day spent on border-crossing procedures of 0.82 [95% confidence bands: 0.002; 1.64] percentage points, which is well in line with the range of estimates obtained in Hummels & Schaur (2013) in their causal effect design study for the US. This result strengthens the confidence in structural specification used in this paper and support claims on the external validity of the results obtained in Hummels & Schaur (2013). Exploiting the disaggregate components of time to export and import, i.e. documents preparation, port and terminal handling and customs and inspection, improves identification and precision of the estimates by focusing on time delays that only affect border-crossing trade. The results suggest that the effects are mainly driven by the time needed to request, assemble and prepare documents for trade. In line with the existing literature, we find that low and middle income countries are expected to benefit most from reductions in time costs. Trade between countries in this income group will show the largest increases according to our counterfactual simulations. The trade facilitation efforts between 2006 and 2012 lead to an increase in welfare of middle/low income countries of 0.74 [95% Confidence bands: 0.42; 1.05] percent and further reductions to 2012 levels of time for the average time for cross-border procedures between high income countries could further increase welfare by 1.5 [0.5; 2.6] percent. Aiming for the international best practice in 2012 could on average even boost welfare in these countries by 3.5 [0.95; 6.1].

Our results also convey policy implications. With multilateral trade liberalization stalling, the number of new regional trade agreements decreasing and uprising tariffs, trade facilitation offers an opportunity to increase trade and welfare that can be taken up unilaterally. Especially low and middle income countries can benefit from increased trade facilitation efforts in terms of improved procedures of doing business internationally. Potential economic policy options to bring down the time needed for import and export procedures include investments in digitization and physical infrastructures accompanied by regulatory reforms. In this respect the WTO Bali Agreement of December 2013 may be seen as an important step forward, since it aims at providing trade facilitation support for developing countries. As with all measures that bring down costs and increase trade, the environmental and distributional impacts should be borne in mind. While the results of this paper point to positive welfare effects for middle and low income countries on average, effects may deviate for particular countries or socio-economic groups within countries. For increasing trade to benefit a large part of the population, factors such as the institutional quality, the quality of the welfare and education system will likely play crucial roles. Hence, our results should be interpreted in this context and not be seen as a panacea against poverty.

The findings of this paper are subject to several limitations that require further research. A particular important limitation is data availability on time and tariffs. Ideally, empirical measures on those variables would vary not only by period but also over country-pairs. Border-crossing procedures can be expected to differ across trading partners and the limitation faced in this study simply arises from the way the Doing Business Survey collects the data. A richer dataset on time to trade would also allow a more flexible model, for instance, with heterogeneous effects by income group. Regarding the tariff measures, while most of the trade between countries within the WTO is subject to the most favored-nation tariff, the recently imposed US tariffs clearly demonstrated that a bilateral perspective, taking into account RTA and custom unions, would be preferable. Furthermore, tariff rates will depend on the specific product and time requirements will exert a different impact on time-sensitive and time-insensitive products. Taking this heterogeneity into account additionally requires product specific domestic trade data to estimate product or sector specific models. This further poses the methodological problem of how to treat country pairs with zero trade flows over all periods, an issue that affects estimation when controlling for directional dyadic fixed effects. A related issue regards a differentiation of the effects between the extensive and intensive margin within a structural gravity framework, potentially extending it to a two-step selection approach with suitable variables obeying the exclusion restriction in the first stage.

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Appendix

A Collinearity of Time to Export and Import in an Unrestricted Specification

TE_A is the time to export and TI_A the time to import of country A. Following Heid et al. (2017), we express $TE \times I$, with I being a dummy indicating international flows, as a linear combination of the dummies and $TI \times I$ (see Heid et al. (2017), eq. (13)) - (setting η_3 as base fixed effect)

$$\alpha_1\eta_1 + \alpha_2\eta_2 + \alpha_3\mu_1 + \alpha_4\mu_2 + \alpha_5\mu_3 + \alpha_6 I + \alpha_7 TE \times I = TI \times I, \tag{2}$$

with TE or TI being perfectly collinear with the rest of the variables if there exists a non-zero solution, $\alpha_1, ..., \alpha_7$ for the system (2). Given the high correlation between TE_A and TI_A, for the following we assume $T_A = TE_A = TI_A$, for countries A, B and C. The matrix (14) on page 14 in Heid et al. (2017) can be written as:

#	ex	im	$\alpha_1\eta_1$	+	$\alpha_2\eta_2$	+	$\alpha_3\mu_1$	+	$\alpha_4\mu_2$	+	$\alpha_5\mu_3$	+	$\alpha_6 I$	+	$\alpha_7 TE \times I$	=	$TI \times I$
1	A	B	α_1	+	0	+	0	+	$-\alpha_2$	+	0	+	α_6	+	$\alpha_7 * T_A$	=	T_B
2	A	C	α_1	+	0	+	0	+	0	+	0	+	α_6	+	$\alpha_7 * T_A$	=	T_C
3	B	A	0	+	α_2	+	$-\alpha_1$	+	0	+	0	+	α_6	+	$\alpha_7 * T_B$	=	T_A
4	B	C	0	+	α_2	+	0	+	0	+	0	+	α_6	+	$\alpha_7 * T_B$	=	T_C
5	C	A	0	+	0	+	$-\alpha_1$	+	0	+	0	+	α_6	+	$\alpha_7 * T_C$	=	T_A
6	C	B	0	+	0	+	0	+	$-\alpha_2$	+	0	+	α_6	+	$\alpha_7 * T_C$	=	T_B
7	A	A	α_1	+	0	+	$-\alpha_1$	+	0	+	0	+	0	+	0	=	0
8	B	B	0	+	α_2	+	0	+	$-\alpha_2$	+	0	+	0	+	0	=	0
9	C	C	0	+	0	+	0	+	0	+	0	+	0	+	0	=	0

whereas $\alpha_5 = 0$, $\alpha_2 = -\alpha_4$ and $\alpha_1 = -\alpha_3$ for the last three domestic equations to hold, and the following solution:

$$\alpha_1 = T_C - T_A \tag{3}$$

$$\alpha_2 = T_C - T_B \tag{4}$$

$$\alpha_6 = \frac{T_A T_C - T_C T_A}{T_A - T_C} = 0 \tag{5}$$

$$\alpha_7 = \frac{T_A - \alpha_6}{T_A} = 1 \tag{6}$$

Hence, if $TE_{ct} = TI_{ct}$ for countries $c = 1, ..., C$ and periods $t = 1, ..., T$ then TE and TI cannot separately be identified. Given that the correlation for total time is 0.96, for border time 0.94 and for documents 0.95, collinearity will be an issue in an unrestricted model with $\delta_{EXPORTER} \neq \delta_{IMPORTER}$.

B Identification of Non-discriminatory Variables in Exponential Models

Consider the exponential gravity model:

$$\begin{aligned} y_{ij} &= \underbrace{\exp(\beta_0 + x_{ij}'\beta_1 + b_{ij}z_{i1}\gamma_1 + b_{ij}z_{j2}\gamma_2 + \underbrace{\mu_i + \lambda_j}_{fixed\ effects})}_{m_{ij}(\theta)}(1 + \xi_{ij} + \underbrace{\nu_i + \phi_j}_{random\ effects}) \\ &= m_{ij}(\theta) + m_{ij}(\theta)\left(\xi_{ij} + \nu_i + \phi_j\right). \end{aligned}$$

Since z_1 and z_2 exhibit unilateral variation only, endogeneity might occur if there are unobserved exporter and importer specific random shocks that are correlated with z_1 and z_2, i.e., one can decompose the disturbances as $1+\xi_{ij}+\nu_i+\phi_j$. Thereby, the $\xi_{ij}'s$ are assumed to be independent country-pair specific random variables, while ν_i and ϕ_j are independent exporter and importer country specific random effects. Similar to the Hausman & Taylor (1981) set-up for linear models, it is assumed that $E[\xi_{ij}\nu_i] = E[\xi_{ij}\phi_j] = 0$, $E[\xi_{ij}|x] = 0$, $E[\xi_{ij}|z] = 0$, but $E[\nu_i|z_{i1}, x] \neq 0$, $E[\phi_j|z_{j2}, x] \neq 0$. Lastly, b_{ij} stands for the border dummy taking the value 1 if $i \neq j$ and 0 else. Since the dependent variable is a share, we assume the normalization $m_{ij}(\theta) = O(C^2)$ and $1 + \xi_{ij} + \nu_i + \phi_j = o_p(C^2)$.
In matrix notation the econometric model reads

$$\begin{aligned} \ln m &= X\beta + D\mu + \underbrace{B\left(D_x z_1\gamma_1 + D_m z_2\gamma_2\right)}_{B\left[\begin{array}{cc} D_x & D_m \end{array}\right]\left[\begin{array}{cc} z_1 & 0 \\ 0 & z_2 \end{array}\right]\left[\begin{array}{c} \gamma_1 \\ \gamma_2 \end{array}\right] = BDZ\gamma} \\ &= \underbrace{X\beta + BDZ\gamma}_{W\theta} + D\mu := W\theta + D\mu \\ y &= m(\theta) + \underbrace{M\left(D_x\eta_1 + D_m\eta_2\right.}_{\left[\begin{array}{cc} D_x & D_m \end{array}\right]\left[\begin{array}{c} \eta_1 \\ \eta_2 \end{array}\right] = D\eta} + \xi) \\ &= m + M\left(D\eta + \xi\right) \end{aligned}$$

where D_x collects exporter dummies and D_m importer dummies, $M = diag(m_{ij})$ and $B = diag(b_{ij})$. Now consider the moment conditions implied by PPML and their linearization following Windmeijer & Silva (1997). Applying the mean value theorem yields

$$\left[\begin{array}{c} W'(y-\widehat{m}) \\ D'(y-\widehat{m}) \end{array}\right] = \left[\begin{array}{c} W'M_0\left(D\eta+\xi\right) \\ D'M_0\left(D\eta+\xi\right) \end{array}\right] + \left[\begin{array}{cc} W'M^*W & W'M^*D \\ D'M^*W & D'M^*D \end{array}\right]\left[\begin{array}{c} \widehat{\theta}-\theta_0 \\ \widehat{\mu}-\mu_0 \end{array}\right].$$

The formula for partitioned inverses implies

$$\begin{aligned} \widehat{\theta}-\theta_0 &= \left(W'M^*W - W'M^*D\left(D'M^*D\right)^{-1}D'M^*W\right)^{-1} \\ &\quad *\left(W' - W'M^*D\left(D'M^*D\right)^{-1}\right)M_0\left(D\eta+\xi\right) \\ &= \left(W'\underbrace{\left(M^* - M^*D\left(D'M^*D\right)^{-1}D'M^*\right)}_{Q_{M_0^{1/2}D}}M^{*-1}M_0W\right)^{-1} \\ &\quad *W'\left(M^* - M^*D\left(D'M^*D\right)^{-1}D'M^*\right)M^{*-1}M_0\left(D\eta+\xi\right) \\ &= \left(W'M^{*\frac{1}{2}}Q_{M^{*1/2}D}M^{*\frac{1}{2}}W\right)^{-1}W'M^{*\frac{1}{2}}Q_{M^{*1/2}D}M^{*\frac{1}{2}}\left(\xi + M^{*-1}(M_0-M^*)\xi\right) \\ &= \left(W'M^{*\frac{1}{2}}Q_{M^{*1/2}D}M^{*\frac{1}{2}}W\right)^{-1}W'M^{*\frac{1}{2}}Q_{M^{*1/2}D}M^{*\frac{1}{2}}\xi + o_p(1), \end{aligned}$$

since $Q_{M_*^{1/2}D} M_*^{\frac{1}{2}} D\eta = 0$. So exporter and importer specific shocks are projected out and $\widehat{\theta}$ can be estimated consistently. This result implies that the parameters of exporter and importer specific variables are not identified and cannot be estimated. However, the parameters of interactions like BDZ are identified and the corresponding parameters can be estimated consistently provided $E[\xi_{ij}|B, D] = 0$.

C Descriptive Statistics and Correlations

Table 8: Summary Statistics

	mean	sd	min	max
s	0.0003	0.0043	0	0.2494
$B * \ln TT^{TOTAL}$	2.6140	0.5299	0	4.4031
$B * \ln TT^{BORDER}$	2.3974	0.5140	0	3.8044
$B * \ln TT^{DOCUMENTS}$	1.9012	0.5329	0	3.3962
$B * \ln TT^{TERMINAL}$	0.8470	0.3994	0	2.5185
$B * \ln TT^{CUSTOMS}$	0.5443	0.4459	0	2.6020
$B * \ln(1 + MFN) * (1 - CU)$	0.0554	0.0433	0	0.2167
$B * \mathbb{1}[t := 2009]$	0.3280	0.4695	0	1
$B * \mathbb{1}[t := 2012]$	0.3280	0.4695	0	1
$B * \mathbb{1}[t := 2009] * CB$	0.0122	0.1097	0	1
$B * \mathbb{1}[t := 2012] * CB$	0.0122	0.1097	0	1
$B * \mathbb{1}[t := 2009] * \ln(DIST)$	2.7739	4.0087	0	9.8814
$B * \mathbb{1}[t := 2012] * \ln(DIST)$	2.7739	4.0087	0	9.8814
$B * RTA_{t-1}$	0.3091	0.4621	0	1.0000
Observations	11826			

Table 9: Pairwise triple-demeaned correlation of variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) s	1.00							
(2) $B * \ln TT_{TOTAL}$	-0.08	1.00						
(3) $B * \ln TT_{BORDER}$	-0.08	0.97	1.00					
(4) $B * \ln TT_{DOCUMENTS}$	-0.08	0.95	0.97	1.00				
(5) $B * \ln TT_{TERMINAL}$	-0.08	0.74	0.79	0.66	1.00			
(6) $B * \ln TT_{CUSTOMS}$	-0.03	0.85	0.84	0.77	0.63	1.00		
(7) $B * \ln(1 + MFN) * (1 - CU)$	0.01	0.39	0.42	0.38	0.37	0.42	1.00	
(8) $B * RTA_{t-1}$	-0.11	-0.40	-0.40	-0.39	-0.24	-0.45	-0.39	1.00

Exporter-time, importer-time and exporter-importer means removed.

D Alternative Functional Forms

Table 10: Parameter estimates from panel data CPPML, $TT_{ijt} = B_{ijt} * \ln(TE_{it} + TI_{jt})$

	(1)			(2)			(3)			(4)		
	coef.	t-val.		coef.	t-val.		coef.	t-val.		coef.	t-val.	
$B * \ln(TT^{TOTAL})$	-0.34	-3.46	***									
$B * \ln(TT^{BORDER})$				-0.41	-3.75	***						
$B * \ln(TT^{DOCUMENTS})$							-0.25	-3.10	***	-0.29	-3.72	***
$B * \ln(TT^{TERMINAL})$							-0.10	-0.84				
$B * \ln(TT^{CUSTOMS})$							-0.08	-1.01				
$B * \ln(1 + MFN) * (1 - CU)$	-5.52	-2.12	**	-5.32	-2.17	**	-5.28	-2.14	**	-5.78	-2.30	**
$B * \mathbb{1}[t := 2009]$	0.15	1.44		0.15	1.43		0.16	1.50		0.14	1.31	
$B * \mathbb{1}[t := 2012]$	0.15	1.09		0.13	0.95		0.13	0.95		0.13	0.95	
$B * \mathbb{1}[t := 2009] * CB$	-0.03	-0.80		-0.03	-0.72		-0.03	-0.70		-0.03	-0.81	
$B * \mathbb{1}[t := 2012] * CB$	-0.16	-2.81	***	-0.15	-2.88	***	-0.15	-2.96	***	-0.15	-2.93	***
$B * \mathbb{1}[t := 2009] * \ln(DIST)$	-0.03	-1.81	*	-0.03	-1.92	*	-0.03	-2.07	**	-0.03	-1.78	*
$B * \mathbb{1}[t := 2012] * \ln(DIST)$	0.03	1.26		0.03	1.28		0.03	1.28		0.03	1.28	
$B * RTA_{t-1}$	0.04	1.20		0.04	1.10		0.04	1.09		0.04	1.33	

Notes: The panel comprises 3 periods of 3-year intervals and 63 countries with with 131 out of 11,826 missing trade flows. Standard errors are clustered over country-pairs, importer-years and exporter-years. *,**,***... Significant at 10%-, 5%- and 1%-level.

Table 11: Parameter estimates from panel data CPPML, $TT_{ijt} = B_{ijt} * \ln(TE_{it})$

	(1)			(2)			(3)			(4)		
	coef.	t-val.		coef.	t-val.		coef.	t-val.		coef.	t-val.	
$B * \ln(TT_{TOTAL})$	-0.22	-2.19	**									
$B * \ln(TT_{BORDER})$				-0.34	-2.81	***						
$B * \ln(TT_{DOCUMENTS})$							-0.12	-1.58		-0.17	-2.03	**
$B * \ln(TT_{TERMINAL})$							-0.21	-1.98	**			
$B * \ln(TT_{CUSTOMS})$							-0.19	-1.72	*			
$B * \ln(1 + MFN) * (1 - CU)$	-6.12	-2.15	**	-5.90	-2.16	**	-5.16	-1.95	**	-6.36	-2.26	**
$B * \mathbb{1}[t := 2009]$	0.13	1.24		0.13	1.16		0.15	1.41		0.11	1.03	
$B * \mathbb{1}[t := 2012]$	0.14	1.03		0.12	0.82		0.13	0.95		0.12	0.81	
$B * \mathbb{1}[t := 2009] * CB$	-0.03	-0.75		-0.03	-0.71		-0.02	-0.57		-0.03	-0.78	
$B * \mathbb{1}[t := 2012] * CB$	-0.16	-2.76	***	-0.16	-2.77	***	-0.15	-2.74	***	-0.16	-2.75	***
$B * \mathbb{1}[t := 2009] * ln(DIST)$	-0.02	-1.57		-0.02	-1.59		-0.03	-1.84	*	-0.02	-1.42	
$B * \mathbb{1}[t := 2012] * ln(DIST)$	0.03	1.38		0.03	1.45		0.03	1.43		0.03	1.50	
$B * RTA_{t-1}$	0.04	1.24		0.04	1.27		0.03	0.99		0.05	1.30	

Notes: The panel comprises 3 periods of 3-year intervals and 63 countries with with 131 out of 11,826 missing trade flows. Standard errors are clustered over country-pairs, importer-years and exporter-years. *,**,***... Significant at 10%-, 5%- and 1%-level.

E Calculation of Ad Valorem Tariff Equivalents

For ease of exposition we skip the time index. Let $\Delta t_{ij} = t_{ij}^C - t_{ij}$ define the change of the tariff equivalent as a response to the change in the time to export and import indicators. Furthermore, using the parameter estimates $\widehat{\delta}$ and $\widehat{\tau}$ the estimated change of the tariff equivalent in percent is defined as $\exp\left(\frac{\widehat{\delta} B_{ij}\Delta TT_{ij}}{\widehat{\tau}}\right) - 1$. Then, the estimated change of the tariff equivalent in percentage points and its linearization are given as:

$$\widehat{\Delta t_{ij}} = t_{ij}\left(\exp\left(\frac{\widehat{\delta} B_{ij}\Delta TT_{ij}}{\widehat{\tau}}\right) - 1\right) = t_{ij}\left(\exp\left(\frac{\delta_0 B_{ij}\Delta TT_{ij}}{\tau_0}\right) - 1\right)$$
$$+\underbrace{\left[\begin{array}{cc} t_{ij}\exp\left(\frac{\delta_0 B_{ij}\Delta TT_{ij}}{\tau_0}\right) B_{ij}\Delta TT_{ij}, & -t_{ij}\exp\left(\frac{\delta_0 B_{ij}\Delta TT_{ij}}{\tau_0}\right)\frac{1}{\tau_0^2} B_{ij}\Delta TT_{ij} \end{array}\right]}_{H_{ij}}\left[\begin{array}{c} \widehat{\delta} - \delta_0 \\ \widehat{\tau} - \tau_0 \end{array}\right] + o_p(1).$$

Thereby, the base t_{ij} is observed and treated as non-stochastic. Using the Selection matrix S to obtain averages for groups of country pairs and collecting Δt_{ij} the H_{ij} in the vector Δt and the matrix H, respectively, the percentage change in the tariff equivalent for country group averages can be compactly written as

$$\widehat{\Delta t} = S\Delta t_0 + SH\left[\begin{array}{c} \widehat{\delta} - \delta_0 \\ \widehat{\tau} - \tau_0 \end{array}\right].$$

The delta method implies that

$$S(\Delta t - \Delta t_0) \overset{asy}{\sim} N(0, S' H_0 V H_0' S)$$

were $V = Var\left(\left[\begin{array}{c} \widehat{\delta} - \delta_0 \\ \widehat{\tau} - \tau_0 \end{array}\right]\right)$. In order to obtain the confidence intervals for $S\Delta t$ reported in Tables 5 and 13 we plug in $\widehat{H}$ for H_0 and $\widehat{V}$ for V.

F Counterfactual Scenarios for Specification (2): Border Time

Table 12: Scenario descriptions, change in mean time to trade of Specification (2)

	Baseline	Counterfactual	Difference
Scenario 1: TT^{BORDER} at 2006 levels			
Middle/Low - Middle/Low	19.6	15.0	-4.6
Middle/Low - High	12.0	9.8	-2.1
High - Middle/Low	13.3	11.2	-2.1
High - High	8.0	7.3	-0.7
Scenario 2: Mean TT^{BORDER} High-High in 2012			
Middle/Low - Middle/Low	15.0	7.1	-7.9
Middle/Low - High	9.8	7.0	-2.9
High - Middle/Low	11.2	7.0	-4.2
High - High	7.3	7.3	0.0
Scenario 2: Min TT^{BORDER} in 2012			
Middle/Low - Middle/Low	15.0	4.5	-10.5
Middle/Low - High	9.8	4.5	-5.4
High - Middle/Low	11.2	4.5	-6.8
High - High	7.3	4.5	-2.8

Note: Table contains group means of $\exp(0.5 * \ln(TE_{it} * TI_{jt}))$

Table 13: Direct effects on international trade with tariff equivalent, Specification (2)

	International Trade			Tariff Equivalent		
Exporter - Importer	%-change	CI-lower	CI-upper	pp-change	CI-lower	CI-upper
			Scenario 1: TT^{BORDER} at 2006 levels			
Middle/Low - Middle/Low	10.65	3.13	18.17	-1.90	-3.78	-0.01
Middle/Low - High	7.25	2.21	12.29	-1.27	-2.54	-0.01
High - Middle/Low	6.50	2.00	11.00	-1.18	-2.36	-0.005
High - High	3.28	1.04	5.52	-0.58	-1.16	-0.001
			Scenario 2: Mean TT_{BORDER} High-High in 2012			
Middle/Low - Middle/Low	29.80	7.07	52.53	-4.83	-9.55	-0.10
Middle/Low - High	12.04	3.49	20.59	-2.06	-4.10	-0.02
High - Middle/Low	17.09	4.68	29.49	-2.94	-5.84	-0.04
High - High	0.00	0.00	0.00	0.00	0.00	0.00
			Scenario 3: Min TT_{BORDER} in 2012			
Middle/Low - Middle/Low	53.99	9.35	98.64	-7.87	-15.45	-0.28
Middle/Low - High	32.08	7.40	56.77	-4.97	-9.83	-0.11
High - Middle/Low	38.54	8.21	68.86	-5.99	-11.81	-0.16
High - High	18.65	5.03	32.28	-3.05	-6.06	-0.04

Notes: Two-sided 95%-confidence intervals are calculated using the delta method. pp ... percentage point.

Table 14: Full endowment general equilibrium effects on international trade, Specification (2)

	%-change	CI-lower	CI-upper
Scenario 1: TT^{BORDER} at 2006 levels			
Middle/Low - Middle/Low	5.84	-0.67	12.35
Middle/Low - High	5.75	-0.40	11.89
High - Middle/Low	2.23	0.13	4.34
High - High	2.24	0.46	4.02
Scenario 2: Mean TT^{BORDER} High-High in 2012			
Middle/Low - Middle/Low	16.56	-0.53	33.65
Middle/Low - High	12.17	-2.17	26.51
High - Middle/Low	2.99	0.56	5.43
High - High	-2.27	-3.13	-1.42
Scenario 3: Min TT^{BORDER} in 2012			
Middle/Low - Middle/Low	24.94	-1.73	51.62
Middle/Low - High	21.61	-3.52	46.73
High - Middle/Low	8.64	1.25	16.03
High - High	5.55	-0.68	11.77

Note: Two-sided 95%-confidence intervals are calculated using the delta method.

Table 15: Full endowment general equilibrium effects on domestic trade and welfare, Specification (2)

	Domestic Trade			Welfare		
Income Group	%-change	CI-lower	CI-upper	%-change	CI-lower	CI-upper
			Scenario 1: TT^{BORDER} at 2006 levels			
Middle/Low	-4.53	-5.67	-3.39	1.00	0.69	1.31
High	-1.04	-1.58	-0.50	0.22	0.09	0.35
			Scenario 2: Mean TT_{BORDER} High-High in 2012			
Middle/Low	-10.75	-14.93	-6.58	2.47	1.31	3.63
High	-2.28	-3.14	-1.41	0.49	0.28	0.71
			Scenario 3: Min TT_{BORDER} in 2012			
Middle/Low	-19.65	-28.05	-11.25	4.80	2.19	7.41
High	-11.17	-16.56	-5.78	2.57	1.10	4.04

Note: Two-sided 95%-confidence intervals are calculated using the delta method.