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Value-Added Gains from Trade Facilitation: Evidence from Developing Countries in Africa and Asia

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Abstract

This paper evaluates the effects of foreign trade facilitation on gross exports and value added. Based on a gravity model of trade, we firstly estimate sectoral gross-trade elasticities to the time it takes to import and export. We secondly translate those elasticities into sectoral value-added gains using an input-output framework, accounting for the global fragmentation of production. We distinguish between sectoral value-added effects derived from exports by the sector itself, from indirect exports via other sectors of the same country and from linkages into other countries' stimulated exports. Overall, we find relatively large potential benefits. Yet, lacking forward linkages into other countries' stimulated exports and the initial export specialisation are drivers of cross-country differences. The sectoral structure of the value-added benefits depends additionally on exporters' backward linkages, which we find to be highly heterogeneous across countries.

Keywords: Gravity, Trade Policy, Global Value Chain, Development, Africa, Asia.
JEL codes: F1, F14, F62, F63, F68, O14, O24.

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1. Introduction

In 2003, the WTO initiated talks on the Trade Facilitation Agreement, which came into force in 2017 with ratification by almost 90% of the member states. Trade facilitation has the broad goal of facilitating trade across borders through simplification, harmonisation and improvement of rules, regulations and infrastructure. This might be particularly relevant for developing countries, as it is often argued that their exports are indeed strongly constrained by poor trade facilitation, such as slow custom procedures (e.g., Christ and Ferrantino, 2011; Freund and Rocha, 2011). Focussing on Africa, Freund and Rocha (2011), for example, find that reducing transport times by one-day increases gross exports by 7%. Reduction of such trade barriers might further be particularly relevant because many developing countries already benefit from preferential access agreements, such that non-tariff barriers account for the bulk of trade costs. Implementation of the WTO agreement can thus be an effective tool to decrease trade costs generating exports and growth. Yet, implementation is typically difficult and might require substantial development aid in many developing countries (Helble et al., 2012; Hillberry and Zhang, 2018).

Given this prominence of trade facilitation and the potentially costly implementation, it is important to evaluate the expected benefits. This evaluation is the goal of this paper with a focus on a set of low and lower-middle income countries from Africa and Asia (Ethiopia, Kenya, Senegal, Bangladesh, China, India, Indonesia, Vietnam). While there are a number of studies on the gross-export effects of trade facilitation,[1] this paper seeks to contribute by studying trade facilitation in the context of production fragmentation. This is important as the traditional approach based on gross exports only may yield misleading results with respect to the net impact on the domestic economy and with respect to the distribution of impacts across sectors.

In recent decades, production increasingly fragmented within and across countries (e.g., Hummels et al., 2001; Johnson and Noguera, 2017; Pahl and Timmer, 2019). Products used to be fully finalised within single countries and typically even by single firms. Today, a finalised product embodies contributions from multiple firms in multiple sectors within the producing country and similarly from firms in multiple sectors in other countries. This has three main implications for the evaluation of trade effects. Firstly, gross trade figures no longer accurately

[1] For example Djankov et al. (2010), Freund and Rocha (2011), Heid et al. (2017), Hornok and Koren (2015), Martinez-Zarzoso and Marquez-Ramos (2008), Oberhofer et al. (2018), Portugal-Perez & Wilson (2012).

reflect a country's benefits as exports potentially embody a large share of foreign value added, because exporters typically require imported intermediates. This foreign value-added content in total exports of the three African countries ranges between 20 and 35 percent since 1995 (Foster-McGregor et al., 2015) and reaches, for example, up to 25 to 30 percent in China and Bangladesh (e.g., Pahl and Timmer, 2019). The net value-added impact is thus expected to be considerably smaller than the gross-export effect. Secondly, GVCs give rise to indirect trade effects via third countries. That is, trade barriers between country *i* and *j* might affect country *k* if it supplies intermediates to country *i* that are further exported to country *j*. African countries, for example, are often argued to be relatively upstream in value chains, providing opportunities to benefit from trade effects further downstream (e.g., Del Prete et al., 2018; Foster-McGregor et al., 2015). Whether this translates into additional value-added gains depends on whether they indeed link into other countries' exports that are stimulated by trade facilitation. This third-country effect is not picked up by analyses based on gross exports only. Lastly, a country's product-level exports do not only generate value added in the exporting sector but due to linkages potentially in multiple other sectors. Linkages become more important with rising within-country fragmentation (outsourcing), and can be sizeable in the set of African and Asian countries (e.g., Cali et al., 2016). Focussing on gross exports hides this distribution of the impacts, which is important to understand the sectoral implications of trade policies. Full evaluation of the impact of trade facilitation thus requires to go beyond the gross-export effect and to study the value-added implications.

To evaluate trade facilitation in this context, we use a two-step approach. We firstly obtain novel estimates of sectoral (gross) trade elasticities to trade facilitation. We obtain those from a fully specified sectoral structural gravity equation in the spirit of Yotov et al. (2016), based on 47 countries between 2006 and 2014. Previous attempts to estimate sectoral elasticities for trade facilitation are hampered by lack of information on internal trade at the sectoral level (as pointed out by Oberhofer et al., 2018). We are able to overcome this problem because our data is obtained from a panel dataset of global input-output tables that fully account for domestic trade flows, importantly newly including the set of lower income African and Asian countries (constructed in Pahl et al., 2019). We measure trade facilitation by the widely used summary indicator of the World Bank's Trading Across Borders (TAB) dataset (World Bank, 2018a), which indicates the time it takes to import and export (first used by Djankov et al., 2010).[2]

[2] We expect sectoral differences in trade elasticities along the perishability, homogeneity and embeddedness in GVCs of the traded products, which are established motivations for heterogeneity in product-level time

In the second step, we combine the sectoral trade elasticities with the inter-sectoral and inter-country structure of the global input-output tables. We predict first-order changes of gross exports using the obtained sectoral trade elasticities. Based on the input-output structure, we then derive changes in sectoral value added from the predicted changes of gross exports. These value-added changes are split into changes from direct exports, into changes from indirect exports via other sectors and into changes due to stimulated exports of other countries (a third-country effect). Sectoral trade elasticities therefore matter for value-added effects of country *i* through the extent to which its own exports are stimulated, and through stimulated third-country effects. This second step is based on the approach by Vandenbussche et al. (2019) who develop a sector-level input-output model of trade to analyse Brexit. The comparative statics of the model depict first-order trade effects and effects through general equilibrium. We derive value-added gains from first-order gross-trade effects reflecting the first-order effects of the model. The result thus reflects short-run effects with constant production structures and multilateral resistance terms.[3]

For the evaluation of trade facilitation, we investigate by how much sectoral value added would be higher if the countries in our sample unilaterally or globally (that is, all countries in the dataset) reduced export and import time by 5%, and if they adopted best practices. Cross-country differences in the 5% scenario reflect differences in export specialisation and in linkages to domestic and foreign exporters. The best-practices scenario shows the potential maximum benefit from trade facilitation, additionally taking countries' distance to best practices into account.

Evaluating best practices, we find that relatively large potential value-added gains are possible in Vietnam (8.6% of GDP), China (3.6%), Ethiopia (3.4%) and Indonesia (2.4%). In Kenya (1.7%), the potential gains are moderate. They are relatively small in India (1.2%) and Senegal (0.9%), and particularly small in Bangladesh (0.2%). In terms of economic structure, we find that mostly agriculture and services (excluding business services) are stimulated in the three African countries. In the Asian ones, we find stimulation of manufacturing in particular in Vietnam and China, and we find relatively strong stimulation of business services in India and China.

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sensitivity (e.g., Djankov et al., 2010; Hayakawa et al., 2019; Hummels and Schaur, 2013). For a discussion, see section 2.2.

[3] The results do not speak to potential additional effects from trade diversion and value-chain adjustments. For a discussion, see section 5.

This paper relates to a relatively large empirical cross-country literature on trade facilitation. These macro studies focus on aggregate country-level first-order effects, but importantly are silent on the value-added gains from direct and third-country exports, and on the sectoral implications of trade facilitation. A large set of gravity-type studies relies on the World Bank's TAB data. The overall finding is that trading time is negatively associated with gross trade flows (e.g., Djankov et al., 2010, Freund and Rocha, 2011; Heid et al., 2017; Hornok and Koren, 2015; Martinez-Zarzoso and Marquez-Ramos, 2008; Oberhofer et al., 2018; Portugal-Perez & Wilson, 2012). Another set of studies on trade facilitation uses the World Bank's Logistics Performance Index (LPI), such as Arvis et al. (2013), Hoekman and Nicita (2011), Marti et al. (2014) and Ramasamy and Yeung (2019). These studies also find a positive trade effect of trade facilitation, as measured by the LPI. A small number of recent cross-country studies has also investigated trade facilitation using the OECD trade facilitation indicators (e.g., Beverelli et al., 2015; Moise and Sorescu, 2013; 2015). Also these studies find a positive effect of trade facilitation on gross exports at the country level.

This paper is organised as follows. Section 2.1 discusses the methodology based on Vandenbussche et al. (2019) to derive value-added gains of trade facilitation, and 2.2 shows our gravity estimation of the trade elasticities. Section 3 describes the data, where we also discuss aforementioned alternative measures of trade facilitation. In section 4.1, we discuss the empirical gravity results. In 4.2, we discuss the net impact and the sectoral structure in value-added terms, and compare it to predictions based on gross exports. In 5, we discuss potential general-equilibrium (GE) effects that our approach does not speak to and empirically explore value-chain adjustments. Section 6 concludes.

2. Methodology

We firstly use the empirical gravity equation based on gross exports to obtain sectoral trade elasticities with respect to trade facilitation (discussed in 2.2). Based thereupon, we predict gross-export changes and translate those into sectoral value-added changes using input-output linkages. The second step, which we discuss in 2.1, follows Vandebussche et al.'s (2019) empirical approach based on their theoretical model. Their model is based on the Armington assumption that goods from different suppliers (i.e., countries) are imperfect substitutes. This love-for-variety at the country-sector level generates the network effects across countries and sectors, which is important for the empirical application and the reason we follow Vandenbussche et al.'s (2019) framework. Other related frameworks are typically based on Ricardian trade where one country (that is, the most cost-efficient one) supplies one intermediate input to all sourcing countries. These are less suited for analysing the network effects because they typically generate them between sectors but not between country-sectors (see Vandenbussche et al., 2019).[4]

2.1. Value-added effects

We obtain the gross-export effect by multiplying the initial gross-export value with the percentage change in the trade barrier and its trade elasticity (see section 2.2 for estimation details). For trading time (our measure of trade facilitation), this can be written as

$$\Delta\tilde{\pi}_{ik,j} = \varphi_k * \widehat{TT_{i,j}} * \pi_{ik,j,2014} \tag{1}$$

where $\pi_{ik,j,2014}$ are observed exports of sector-*k* products from country *i* to country *j* in year 2014. $\widehat{TT_{i,j}}$ indicates the percentage change in trading time between country *i* and *j* (that is, a compound of export time of country *i* and import time of country *j*, see section 2.2). φ_k is the trade elasticity of sector-*k* products with respect to trade facilitation. $\Delta\tilde{\pi}_{ik,j}$ indicates the predicted value change in exports, where the tilde indicates prediction.[5] We thus predict changes in gross exports using 2014 as the base year.

The next step is to use the input-output system to translate these predicted gross-export changes into value-added terms, which is based on the approach proposed by Vandenbussche et al. (2019). Taking the global production structure as fixed (in the year 2014), we know from the input-output tables how much output is generated in a given sector *k* in country *z* related to production of any sector in any country in the system. This is depicted in the Leontief inverse, $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ where **A** is the matrix of technical input coefficients and **I** an identity matrix. The element in row *z-k* and column *j-s* in **L** ($L_{zk,js}$) depicts how much output is required from

[4] Well-known examples are Allen et al. (2019), Arkolakis et al. (2012), Costinot and Rodriguez-Clare (2014), and Eaton and Kortum (2002).

[5] Note that the implementation of this method does not hinge on sectoral elasticities to trade. We chose to add this layer of heterogeneity following arguments in the literature and we find it to be empirically meaningful (see 2.2).

sector k in country z to produce one unit of output of sector s in country j. Multiplying these elements with (exogenous) changes in output of sector s in country j indicates how much more output is needed from sector k in country z to serve this increase in output. Multiplying this change in output by the value added to gross output ratio (v) of sector k in country z, we obtain the change in value added of sector k in country z induced by the (exogenous) change in output of sector s in country j. As this description indicates, this hypothetical change relies on the assumption that these changes in output have no bearing on the production technologies, and we treat them as exogenous shocks to the input-output system. In this case, we can write the value-added changes in response to changes of gross exports of sector k in country z as follows.[6]

$$\Delta\widetilde{va}_{zk} = v_{zk} * \sum_{i=1}^{N}\sum_{s=1}^{S}\sum_{j=1}^{N} L_{zk,is} * \Delta\tilde{\pi}_{is,j} \tag{2}$$

where N is the number of countries and S the number of sectors, i and j are country indicators, s is the sector indicator, and $\Delta\widetilde{va}$ indicates the predicted value change in value added.

We decompose the change in sectoral value added of equation 2 into changes due to exports by the sector itself (direct exports), changes due to indirect exports via other sectors of country z and into changes due to exports of other countries i.

$$\Delta\widetilde{va}_{zk} = \underbrace{v_{zk} * L_{zk,zk} * \sum_{j=1}^{N} \Delta\tilde{\pi}_{zk,j}}_{Direct\ export\ effect} + \underbrace{v_{zk} * \sum_{s=1\backslash\{k\}}^{S}\sum_{j=1}^{N} L_{zk,zs} * \Delta\tilde{\pi}_{zs,j}}_{Indirect\ export\ effect} + \underbrace{v_{zk} * \sum_{i=1\backslash\{z\}}^{N}\sum_{s=1}^{S}\sum_{j=1}^{N} L_{zk,is} * \Delta\tilde{\pi}_{is,j}}_{Third-country\ export\ effect} \tag{3}$$

The first term is the value-added change due to changing exports of sector k in country z (*direct export effect*). The second term is the value-added change due to changing exports of any sector s other than k (indicated by $\backslash\{k\}$) in country z (*indirect export effect*). The third term is the value-added change due to changing exports between any country i other than z and all countries

[6] See appendix in Vandenbussche et al. (2019) for a derivation of this expression from an input-output representation.

j (including country *z*; *third-country export effect*). Without production fragmentation within and across countries, the direct export effect is the same as the gross-trade effect. All value added generated in exports would be generated by one firm in the exporting sector. Thereby, the increase in value added of sector *k* would be entirely due to increases in exports of sector *k*, which would also equal the increase in gross exports. With fragmentation within countries (outsourcing), the indirect export effect becomes important because indirectly linked domestic firms contribute to export production. These can be classified in different sectors than the exporting firm, and thereby value added in sector *k* could increase due to exports of other sectors too. Yet, while the sectoral prediction in value-added terms would already differ from the gross-export one, the first two terms would still add up to the gross export value at the country level (summed over all sectors). With cross-border fragmentation (offshoring), however, the first important difference is that the sum of these terms would be lower than the gross-export change and thereby predict lower net impacts. The size of each sector's value-added gain is thus depressed by the extent of foreign sourcing. Secondly, cross-border fragmentation gives rise to the third-country export effects. This term is lacking in gross-export considerations as it describes value-added changes due to export changes of other countries. Without cross-border fragmentation, this term does not exist because no country sources foreign intermediates to export. This term thus gives rise to additional value-added effects to countries that are heavy suppliers of intermediates that feed into other countries' (stimulated) exports.

Let us assume that trade facilitation makes it easier to export processed food from country *i* and, as a results, exports from the food manufacturing industry rise. This increase in exports leads to an increase in value added of food manufacturing in country *i*, the direct export effect. In addition, demand rises for inputs into food manufacturing, for example, grain. If grain is produced in country *i*, this gives rise to an indirect export effect. If the grain is imported from abroad, say from country *j*, this will not increase value added for country *i* in question, but instead for country *j* through the third-country export effect.

2.2. Sectoral trade elasticities

To implement equations 1 to 3, we need to obtain sectoral trade elasticities, which we retrieve through state-of-the-art gravity estimation. Our empirical model is close to Oberhofer et al. (2018) who estimate the effect of trading time on gross-trade flows at the country level. We estimate it at the sector level. Similar to their econometric model, our approach does justice to all suggestions of Piermartini and Yotov (2016) and Yotov et al. (2016). Our data are a panel dataset covering 47 countries with 17 manufacturing and 9 other broad sectors between 2006 and 2014. We estimate the gravity specification at the sector level for the set of manufacturing industries and agriculture. As our data is obtained from global input-output tables, it is straightforward to obtain data for internal trade, also at the sector level. Further, to allow for equilibrium adjustments in trade flows, we use data for 2006, 2010, and 2014 in our baseline specification. As is standard in the literature, we use the PPML estimator from Silva & Tenreyro (2006), which can deal with zero trade flows and heteroscedasticity. Lastly, the sectoral panel structure allows for inclusion of exporter-sector-year, importer-sector-year and exporter-sector-importer fixed effects, accounting for the so-called multilateral resistance terms (and controlling for unobserved heterogeneity along those dimensions). The baseline specification is as follows.

$$\pi_{ik,j,t} = \exp\{\beta_1 B_{i,j} * \ln TT_{i,j,t} + \boldsymbol{\omega} B_{i,j} * \ln TT_{i,j,t} * \mu_g + \beta_2 B_{i,j} * CU_{i,j,t-1} + \beta_3 B_{i,j} * FTA_{i,j,t-1} + \sum_{n=2}^{3} \beta_{2+n} B_{i,j} \mathbb{1}[t=n] + \boldsymbol{\vartheta}\left(\sum_{n=2}^{3} B_{i,j}\mathbb{1}[t=n] * \ln DIST_{i,j}\right) * \mu_g + \sum_{n=2}^{3} \beta_{4+n} B_{i,j}\mathbb{1}[t=n] * CNTG_{i,j} + \theta_{ik,t} + \delta_{k,j,t} + \gamma_{ik,j}\} * \varepsilon_{ik,j,t} \quad (4)$$

where $\pi_{ik,j,t}$ are exports from sector *k* of country *i* to country *j* at time *t*. *t* are three years 2006, 2010, and 2014. The main variable of interest is $\ln TT_{i,j,t}$, the measure of trading time constructed as $\ln TT_{i,j,t} = 0.5 * \ln(XT_{i,t} * MT_{j,t})$ where $XT_{i,t}$ is the export time of country *i* at time *t* and $MT_{j,t}$ is the import time of country *j* at time *t*. $B_{i,j}$ is a dummy that takes the value one if trade crosses an international border, and is zero otherwise. By interacting it with trading time, trading time is zero when trade is internal, as internal trade does not go through border procedures. Through the second term, we identify the sectoral trade elasticities. We interact the measure of trading time with dummies for groups of exporting sectors (μ_g, with *g* being a set of exporting sectors *k*). The coefficients are collected in $\boldsymbol{\omega}$. β_1 and element ω_k thus provide the elasticity to trading time for sector *k*, which we use to recover the value-added changes, as explained in the previous section.[7]

We let the elasticities to trading time vary by groups of sectors to uncover heterogeneity at this level. Following the three main motivations in the literature for sector-level heterogeneity of time sensitivity, we pool the exporting sectors in four groups: agriculture, homogenous

[7] In equation 1, $\varphi_k = \beta_1 + \omega_k$.

manufacturing (petrol, rubber, minerals, basic metals, fabricated metals, wood), in industries of complex GVC trade (computer, electrical equipment, machinery, motor vehicles and transport equipment), and in industries of simple GVC trade (food, textiles, paper, chemicals, pharmaceuticals, other manufacturing including furniture). The first argument in the literature is perishability of goods. Perishability is associated with fast depreciation and thereby makes timely delivery paramount (e.g., Djankov et al., 2010; Hummels and Schaur, 2013). This is mainly important for fresh agricultural products. Given our focus on developing countries, which typically have a large agricultural sector, agriculture is important to understand the implications for the domestic economy if affected by trade facilitation. We expect a relatively large elasticity for agricultural products.

A second dimension in the literature is whether goods are homogenous, which are argued to be more sensitive to time. If additional time at the border implies additional storage costs that are passed through, this increases the price of the traded good. As homogenous goods face a higher price elasticity of demand than differentiated goods, the effect of additional time spent at the border is thus stronger. Empirical evidence has typically been provided in favour (e.g., Hayakawa et al., 2019) but in some cases against this hypothesis (e.g., Martinez-Zarzoso and Marquez-Ramos, 2008). Measurement is typically based on Rauch (1999) who classifies goods as differentiated if they are neither reference priced nor sold on organised exchange. According to this classification, homogenous goods are typically resource-based products and primary commodities. We therefore expect industries of more homogenous products to be relatively time sensitive, which, in our data, we consider to be petrol, rubber, minerals, basic metals, fabricated metals and wood.[8]

The third explanation of time sensitivity loosely relates to trade in global value chains (GVCs) (e.g., Hummels and Schaur, 2013; Oberhofer et al., 2018). The general idea is that production arrangements within GVCs are more sensitive to time because firms need to optimise value chains as they potentially pay trade costs multiple times if intermediates travel through multiple countries before finalisation of the good (e.g., in the spirit of Yi, 2003; 2010). A second argument is that firms strive to keep their value chains agile. This means that firms

[8] We do not include the mining sector in the analysis, which can also be considered homogenous. Yet, one might argue that trade of mining products is endowment-driven rather than being well described by a gravity analysis. Gravity equations based on mining oftentimes produce implausible results (e.g., as indicated by Aichele et al., 2016). Furthermore, the mining sector plays only a minor role in all studied countries, except Indonesia. Senegal, which has the largest exporting mining sector of our set of African countries, has a mining share in goods exports similar to Croatia. We also aggregate the paper and print industries. Products of print are rarely traded internationally, such that exports are low on average and the sector consists of many bilateral zero trade flows (we refer to the aggregate as paper).

aim to be able to quickly adapt to unforeseen circumstances, which is easier with smaller frictions due to lower trading time for example. Lastly, time costs are often loosely linked to just-in-time production in GVCs, which would provide additional scope for minimising time costs in GVCs (e.g., Oberhofer et al., 2018). Yet, while global input-output tables have enabled tracking global trade flows, it remains an open question how to define and measure GVC trade as opposed to standard trade.[9] In the spirit of Yeats (1998), we follow the more general idea that parts and component trade is characteristic of deeply embedded GVCs, in contrast to simpler GVC trade mainly using primary products as inputs. Hummels and Schaur (2013) use this classification and find that products labelled as 'parts' or 'components' tend to be more sensitive to time. These product descriptions tend to be characteristic for goods in industries of computer, electrical equipment, machinery, motor vehicles and in particular of transport equipment. Gaullier et al. (2019), for example, show that trade of parts and components makes up for a large share of total trade in those industries. We therefore group those manufacturing industries together and expect them to be relatively time sensitive. We group the remaining set of industries as simpler GVC trade, typically importing unprocessed or semi-finished intermediates as inputs (these are food, textiles, paper, chemicals, pharmaceuticals, other manufacturing including furniture). We therefore expect this latter group to have a relatively low elasticity to trading time, as they are also relatively more differentiated than our group of homogenous manufacturing. While these arguments provide a first pass through the data, we acknowledge that they are a matter of degree. Future research would benefit from a more nuanced view into when trading time matters the most, which is a caveat of our (macro) study that we highlight in the conclusion.

Remaining variables in equation 4 are $\sum_{n=2}^{3} B_{ij}\,\mathbb{1}[t=n]$, which are two dummies that take the value one if there is an international border and the year is 2010 (t=2), or 2014 respectively (t=3). These dummies capture the change in the so-called border effect, as countries typically increase international trade compared to internal trade over time (e.g. Baier et al., 2019; Bergstrand et al., 2015). Following Oberhofer et al. (2018), we let the change in the border effect vary by distance and by whether countries have a common border. That is, the border effect might become particularly smaller for countries further away if the cost of distance declines. This is captured in two variables $\sum_{n=2}^{3} B_{ij}\,\mathbb{1}[t=n] * \ln DIST_{ij}$, which are the log of distance in 2010 and 2014 for international trade (zero otherwise). We also let this distance-

[9] While there is by now a vast literature that aims at decomposing trade flows and to assign portions of value added of an industry to traditional trade or to simple or complex GVC trade (e.g., Wang et al., 2017), no consensus has been found.

related border effect vary by industry group, as one might argue that some products benefit more from new technologies that make distance potentially less costly over time. The change in the border effect for neighbouring countries is captured in $\sum_{n=2}^{3} B_{ij}\mathbb{1}[t=n] * CNTG_{ij}$, which takes the value one for neighbouring countries in the respective year. We furthermore control for currency unions (CU_{ijt-1}) and free trade agreements (FTA_{ijt-1}). Both variables are lagged by one period (i.e., 4 years) to allow for phase-in periods, as generally suggested (e.g., Head and Mayer, 2014; Yotov et al., 2016). To account for inward multilateral resistance terms, time-varying importer-sector dummies $\delta_{k,j,t}$ are included, and for outward multilateral resistance terms $\theta_{ik,t}$, time-varying exporter-sector dummies (these also account for mass variables as in traditional gravity, such as GDP). $\gamma_{ik,j}$ are directional pair fixed effects, which account for all time-invariant bilateral trade costs between *i* and *j* for trade flows for products by sector *k*. Pair fixed effects are a common empirical practice to address reverse causality (e.g., of trade agreements), as they absorb effects that stem from historically strong trade relationships (e.g., Baier and Bergstrand, 2007). One might argue that they also pick up trade facilitation efforts between countries due to historically stronger trade ties (e.g., Oberhofer et al., 2018). They also pick up any time-invariant trade cost between countries, such as trading time between borders of bilateral pairs. $\varepsilon_{ik,j,t}$ are the error terms. Standard errors are clustered along the exporter, importer, sector and year dimension.[10]

An important issue with investigating non-discriminatory trade policies, such as any measure of trade facilitation, is that they would drop out from a structural gravity model with exporter-time or importer-time dummies, because they typically only vary over two of the three dimensions.

There are three solutions to this. One approach is to construct a bilateral measure, which we do here for trading time. As the variable also varies over time, $B_{i,j} * \ln TT_{i,j,t}$ varies over all three dimensions, which allows for the full specification of structural gravity. A similar approach has for example been taken in Anderson and Marcouiller (2002) for institutional measures and also in Oberhofer et al. (2018) for trading time. Heid et al. (2017) have recently argued that this is not necessary if one also includes internal trade because the coefficient is identified through the interaction with $B_{i,j}$. However, due to the high correlation of export and

[10] In the appendix Table A1 and A2, we also provide robustness checks by using 3-year periods instead of 4-year periods, by adding tariffs, by using intermediate trade only and by letting all independent variables vary by sector group. In particular, the results on the elasticities of the sector groups are consistent.

import time, it would not be possible to include both measures and one would need to choose whether to investigate export or import time (e.g., Oberhofer et al., 2018). We therefore stick to a bilateral measure for trading time. A third alternative is to use a two-step procedure. In the first step, the gravity equation is estimated including the full set of exporter-time, importer-time and pair dummies. In the second step, the non-discriminatory trade policies are used to explain the pair dummies (e.g., Head and Mayer, 2014), which are used as (theory-consistent) estimates of all bilateral (time-invariant) trade costs. Yet, Heid et al. (2017) emphasise that the asymptotic properties of this approach are not clear yet. But more importantly, such an approach is mainly of interest if the variables do not vary over time, which in fact trading time does. There are several other approaches that have been applied in the literature to include non-discriminatory trade policy variables in gravity estimations, but those come typically at the cost of fully specified structural gravity (e.g., Djankov et al., 2010; Freund and Rocha, 2011; Martinez-Zarzoso and Marquez-Ramos, 2008; Moise and Sorescu, 2013; 2015; Persson, 2008).

A set of recent empirical studies presents a potential alternative to our two-step approach of translating gross-trade effects into value-added effects to account for global production fragmentation and for the differences between gross exports and value added. These studies estimate a reduced-form empirical gravity equation by replacing gross trade flows directly by value-added trade flows to obtain the response of value added to trade barriers (e.g., Brakman et al., 2018; Johnson and Noguera, 2017; Kohl, 2019; Laget et al., 2018; Lee, 2019).[11] Hence, this reduced-form equation implicitly assumes that there is a general, average elasticity of the value-added content of exports (per unit of gross exports) to trade barriers. However, the theoretical reasoning for such a process has not yet been established, and interpretation is therefore difficult. Without a theoretical background, it is not clear what kind of adjustment in this value-added content we should expect. For that reason, we stay silent on a possible adjustment and translate the gross-trade elasticity into value-added changes using the observed relationship in the data (through value-added to output ratios and the input-output structure). Yet in section 5, we provide a first empirical exploration of observed adjustments of the underlying production structures over time.

[11] These studies all focus on the role of trade agreements. Another point of discussion in that literature is the choice of the type of value-added measure of trade. For a discussion, see Los and Timmer (2018).

3. Data

Global Input-Output Data

The main data source is the extended WIOD (Timmer et al., 2015b) that covers the period 2000 to 2014, constructed in Pahl et al. (2019). The WIOD maps the world economy in input-output relationships, which allows for mapping direct and indirect trade flows. The WIOD is extended by seven middle and low income countries. These are Ethiopia, Kenya, Senegal, South Africa, Bangladesh, Malaysia and Vietnam. This extension allows us to study the effect of trade facilitation for lower income countries with our input-output-based approach. Pahl et al. (2019) obtain country-specific national supply and use tables from national statistical agencies and international organisations. Based thereupon, the authors construct benchmark input-output tables for at least one year in the relevant time period. These tables are complemented by the careful construction of external data series of value added, gross output, intermediate use, exports, imports, and totals of final consumption categories. The sources include the GGDC 10-Sector Database (Timmer et al., 2015a), UNIDO's Indstat database (2018), UN Official Country Data (UN, 2018b), UN Estimates of Main Aggregates (UN, 2018a), and UN Comtrade (2018). With this data at hand, times series of national input-output tables are estimated. These are subsequently included in the WIOD by subtracting them from the 'rest of the world' block in the WIOD by use of the bilateral trade flows from UN Comtrade mapped to use categories. Importantly, trade flows have been carefully examined. For example, UN Comtrade allows for identification of re-exports, which account for up to 50% of Senegal's exports, but also for considerable shares in some of the other African countries. Such adjustments dramatically affect trade patterns and make them worthwhile, as no value is captured in re-exports. Another example for the careful treatment of country-specific sources is South Africa's trade of gold. It is found that the reported total level of trade in Comtrade is substantially lower for years before 2011 than of 2011 and also compared to other sources reporting trade totals. Careful examination revealed that this is due to lacking trade of several commodities that relate to gold and are mapped to basic metals in our data. With the use of mirror flows and additional adjustments to trade of gold, the authors are able to close the gap to alternative sources providing a more complete picture of South Africa's trade pattern. For an extensive description, see Pahl et al. (2019). This is arguably the only in-depth effort to complement global input-output databases with low-income countries, and a source that additionally carefully treated country-specific issues. This source is therefore particularly suited to obtain country-specific results of low-income countries.

Trade facilitation

To measure trade facilitation, we rely on the well-known and widely used World Bank's Trading Across Borders (TAB) dataset that provides information on the time it takes to import and export (e.g., used in Djankov et al., 2010; Freund and Rocha, 2011: Oberhofer et al., 2018). Djankov et al. (2010) provide a detailed description of the source but we reproduce the key characteristics here. The data are primarily based on a survey of professionals from freight-forwarding companies (while cross-checked with port authorities in a third of the countries). Respondents are asked to provide information on the needed stages of getting the goods from the factory through the border and assign a duration to each of the steps. The main steps include pre-shipment activities (e.g., inspections, technical clearance), inland carriage and handling, terminal handling (including storage), and customs and technical control. For comparability across countries and to avoid special cases, the survey addressed a stylised transaction of a local company (owned by nationals), employing 201 persons and located in the country's largest city. It is not located in an export-processing zone, but is familiar with exporting (more than 10% of sales are exports). The cargo is standard in that it does not need refrigeration, is not hazardous, and requires no special environmental or other safety standards.

The series has a methodological break in 2014, and entries before and after are not comparable. Given the end of our time series of global input-output tables in 2014, we use the data based on the initial methodology. Data following that methodology is available since 2005.

A potential alternative is the World Bank's Logistics Performance Index (LPI). This dataset features, for example, in the World Economic Forum's Enabling Trade Index (e.g., used in Ramasamy and Yeung, 2019). Similar to the TAB data, this index is created through a survey of logistics professionals involved in international freight forwarding. Firstly, the respondents are asked to rate eight foreign countries on six dimensions of logistics performance for exporting on a scale from 1 to 5. The eight countries are determined by the most important import and export markets of the respondent's home country. Secondly, the scores for a given country are averaged over all respondents and principal-component analysis is used to obtain a single score representing the information of the six dimensions. The traded products in this survey refer to 'general merchandise' and thus have similar product scope as the TAB data, excluding products that require special care.[12]

[12] For a detailed description of the methodology, see Appendix 5 in Arvis et al. (2014).

We prefer the TAB data for two reasons. Firstly, the TAB data has the appeal that it is easy to conceptualize and interpret. It focusses on one particular aspect of trade facilitation, that is, the time it takes to trade across borders. Trading time can be interpreted as traditional (iceberg) trade costs that run through storage costs and depreciation (e.g., Carballo et al., 2014; Hayakawa et al., 2019). The LPI also includes other aspects of trade facilitation that may not result in longer trading times but impact trade through other channels. This makes it a more general measure but also more difficult to conceptualise and harder to interpret. Secondly, using numerical scores bears the additional problem that scores might depend on the respondent's benchmarking (e.g., through the comparative set of countries he or she scores). The World Bank aims to address this by having multiple respondents rate a specific country, and complements the data with confidence intervals of about 80%. For many developing countries, the confidence intervals are very large and it is difficult to identify differences across countries and over the years. One needs to keep in mind that the reported time values in the TAB data are also based on the respondents' perceptions, but time is an objective unit of measurement, and thereby easier to compare.

Clearly, improvements on cross-country data on trade facilitation would be highly welcome. A promising new dataset is the OECD's Trade Facilitation Indicators (e.g., Beverelli et al., 2015; used and described in detail in Moise and Sorescu, 2013; 2015). This source provides a score ranging from 0 to 2 on 12 dimensions of trade facilitation. The novelty is that the dimensions relate to the provisions of the WTO's trade facilitation agreement. It would complement sources like the TAB data, as it is close to a *de jure* measure of policies that supposedly facilitate trade. It is constructed by a mix of publicly available sources, information from globally operating freight-forwarding companies (such as the World Bank's indicators) and direct submissions of countries. This source, however, has only been started to be collected and is therefore only available for very recent years.

A second important area of improvement is adding variation by product characteristic. Due to lack of data, we can only apply a country-level measure based on standardised cargo to all products traded. We assume that the measured time costs apply similarly to all industries. It might well be that time costs for specific industries are higher and that countries may not make as much progress for specific product groups as for standardised cargo. This affects our estimated sectoral trade elasticities if there is a systematic bias in the changes of trading time with respect to export changes (since all our regressions are identified through variation over time). Hence, if the trading-time changes for standardised cargo are systematically larger than for products in the respective product group (that is, trading-time changes are overstated by the aggregate measure) in countries with systematically larger export changes of that product group, the estimated elasticity is upward biased. While we have no prior that this would be the case, we acknowledge that this is an important and interesting avenue for future research.

Control variables

Furthermore, we use data on free trade agreements and currency unions as control variables, which is obtained from the Regional Trade Agreements Database from Egger and Larch (2008). Further standard control variables are obtained from CEPII (Mayer & Zignago, 2011). In Table 1, we provide summary statistics of the variables that feed into our regression, based on the final dataset.

Table 1 Summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Exports (π_{ijt})	117,018	903	17,172	0	1,753,450
$B_{ij} * \ln TT_{ijt}$	117,018	2.49	0.51	0	3.78
$B_{ij} * CU_{ijt-1}$	117,018	0.22	0.42	0	1
$B_{ij} * FTA_{ijt-1}$	117,018	0.20	0.40	0	1
$B_{ij}\mathbb{1}[t=n]$	117,018	0.33	0.47	0	1
$B_{ij}\mathbb{1}[t=n] * CNTG$	117,018	0.02	0.13	0	1
$B_{ij}\mathbb{1}[t=n] * lnDIST$	117,018	2.67	3.89	0	9.83

Note: We report the three border effect variables for t=n, as the variables have the same properties in each year.

Source: Author's calculation based on described data.

In Table 2, we provide overall trends in trade facilitation. Table 2 shows the unweighted averages by income groups, as defined by the World Bank, for export (XT) and import time (MT) in the years 2006 and 2014. It further shows the reported scores of the three African and the five Asian countries that we analyse. Overall, the averages decline in all income groups, suggesting that the average country in the world in each income group has become more efficient. It also shows that the higher income level groups tend to have lower trading time, as expected. In absolute terms, it also suggests that countries in the lower income groups made more progress over these past years than the higher income groups, such that countries seem to converge to better practices. The average scores over all countries indicate better trade facilitation in 2014 than in 2006, and the variance has become smaller. Yet, there still seems to be a relatively large gap between the high-income countries and the rest, suggesting large potential gains from trade facilitation.

Ethiopia, Kenya and Senegal are all classified as low-income countries.[13] In terms of trends, Ethiopia and Kenya only improve by three days in export time but Kenya improves a lot in import time. Senegal almost halved its export and import time. In terms of levels, Kenya scores in-between a lower and upper middle income country, and Senegal even compares to an average high-income country (at least in 2014). Ethiopia is somewhat below the low-income average. Bangladesh, India and Vietnam were low-income countries in 2006, China and Indonesia lower-middle income ones. By 2014, they were all lower-middle income ones, and China even an upper-middle one. In 2014, they scored close to the upper-middle income average, except Bangladesh, which scored close to the lower middle-income average. In terms of trends, Bangladesh has improved substantially by reducing its import time from 63 to 34 days. Indonesia, India and Vietnam have improved but slower than for example Senegal, while China has not improved at all according to this measure of trade facilitation. All countries in our sample are still relatively far from best practices of an export time of six days and import time of four days. Yet, Senegal, for example, has less potential to benefit from trade facilitation because it is already relatively closer to best practices. Improving to those six and four days is the scenario of best practices that we analyse in section 4.2 and 4.3.

Table 2. Trends in trade facilitation

	Trading Time (XT/MT)	
	2006	2014
Best practices	6/4	6/4
High income	13/13	11/11
Upper middle income	29/25	23/21
Lower middle income	38/31	30/26
Low income	51/42	43/36
Ethiopia	47/41	44/44
Kenya	29/37	26/26
Senegal	21/27	12/14
Bangladesh	39/63	29/34
China	21/24	21/24
Indonesia	22/27	17/26
India	27/41	16/20
Vietnam	24/23	21/21

Note: Income groups as defined by the World Bank. Sample includes all countries available in the World Bank's TAB data. XT is export time and MT is import time.

Source: World Bank (2018a).

[13] Kenya just became a lower middle income country in 2014, Senegal was a lower middle income country between 2009 and 2014, but is classified as a low-income country again.

4. Results

4.1. Trade elasticities

We start by discussing the results of the estimated trade elasticities with respect to trading time. As indicated in section 2, we use these elasticities to obtain our estimates of potential gains from trade facilitation, which we discuss in section 4.2. Table 3 shows the baseline results. For comparison to previous research, column 1 shows the results based on aggregated trade flows. That is, we aggregate all bilateral trade flows of manufacturing and agriculture and estimate equation 4 at the country level. The included dummies are now exporter-year, importer-year and exporter-importer dummies.

Most recently, Oberhofer et al. (2018) have investigated a variation of column 1 in a similar set up as ours. Their estimate is based on manufacturing trade in three-year periods (2006, 2009, 2012) for a sample of 63 countries. In their baseline specification, a 1% increase in trading time results in 0.31% lower gross trade flows (significant for $p < 0.01$). In their preferred specification based on time spent on preparing documents, a 1% increase in trading time results in 0.24% lower gross trade flows (significant for $p < 0.05$). In our baseline result, we find an elasticity of -0.25 (significant for $p < 0.10$), which is smaller than their baseline effect but similar to their preferred specification based on time spent on documents.[14] Evaluated at the sample mean, one additional day in trading time translates into a decrease of gross trade of 1.8%. This estimate is close to, but a bit higher than other estimates in the literature. In the well-known study by Djankov et al. (2010), one additional day results in 1.3% lower exports.[15] Overall, it is thus reassuring that our baseline effect is close to existing studies. To further evaluate the size of this effect, we compare it to physical distance. As a comparison, a common elasticity of trade to distance is -1 (e.g., Yotov et al., 2016). Given this elasticity, Ethiopia would increase its exports to China by 130% if it was where Vietnam is. If both Ethiopia and China applied best practices of trading time, Ethiopia's exports to China would increase by 50%. Hence, while trading time alone is unlikely to fully compensate for geographic barriers, it may help to a sizeable degree.

[14] In unreported results, we also estimated the country-level regression for the years 2006, 2009, and 2012. The elasticity increases to -0.41, significant at p<0.05. With respect to our sector-group results, we find the same pattern in several cuts of the data (see below).

[15] Persson (2008) for example finds a semi-elasticity of 1%, Martinez-Zarzoso and Marquez-Ramos of 0.2-0.8%, Hummels and Schaur (2013) of 0.9%, Carballo et al. (2016) of 0.4%. The result of 7% by Freund and Rocha (2011) appears to be an outlier, but it explicitly focusses on African countries.

In column 2 of Table 3, we show the results pooled over exporting sectors, and in column 3, we introduce interaction terms for the sector groups. The pooled elasticity is -0.36, which is larger than in column 1. Yet, column 3 shows that this pooled estimate hides important variation across sets of exporting sectors. In Table 4, we report the estimated effects for each group of sectors (that is, $\beta_1 + \omega_g$ and the respective standard error). The baseline group is complex GVC manufacturing with an elasticity of -0.49. From Table 3, the group of simple GVC manufacturing indeed obtains a statistically significantly smaller elasticity, which adds up to essentially zero, and the effect is not statistically different from zero (Table 4). The elasticities for the groups of homogenous manufacturing and for agriculture are not statistically different from that of complex GVC manufacturing, resulting in a statistically significant and negative elasticity with similar magnitude (Table 4). These patterns are thus in line with expectations of the characteristics of GVC trade and of product characteristics of perishability and homogeneity as discussed in section 2. This heterogeneity is important for our set of countries. The African countries, for example, are indeed important exporters of agricultural products, which are stimulated by trade facilitation. Yet, we do not find evidence that that agriculture's downstream industries, such as food and textiles, are stimulated through trade facilitation. This is important because these are also relatively large exporting industries in the African countries and Bangladesh. Yet furthermore, this suggests that these countries may also benefit relatively less from stimulated third-country exports because their large agricultural sectors tend to be forward-linked precisely into food and textiles of other countries (e.g., Pahl et al., 2019).

Our results are largely consistent with previous research on industry-level heterogeneity of time sensitivity by Hummels (2001). Hummels (2001) estimates the effect of longer ocean travel times on the probability to choose air travel (which saves time but is more costly). He finds relatively stronger effects in similar product categories as we do: in complex GVC manufacturing (e.g., transport equipment, road vehicles, electrical, office, industrial and power-generating machinery); in homogenous manufacturing (e.g., plastics, metals, and cork and wood). He only finds very small coefficient in product groups that broadly correspond to our simple GVC manufacturing, such as food and textiles.[16] These results are also consistent with Djankov et al. (2010) who use the estimates of Hummels (2001) to measure time sensitivity and find that those time-sensitive goods are more sensitive to trading time in a cross-country gravity

[16] Additionally he finds relatively stronger effects in essential oil and fertilisers (chemicals in our data), photographic equipment, travel goods, and coal.

equation. In the appendix Tables A1 and A2, we show that the pattern we find is consistent across several specifications, and cuts of the data. We repeat the exercise in 3-year periods, add tariff data, and run the regression for trade of intermediates. Furthermore, we also show all results in group-specific regressions (that is, letting all independent variables vary by sector group).[17]

The effects of the control variables are also in line with expectations, and stable across specifications. Currency unions and trade agreements increase trade. Being in a currency union increases trade by 33.6% to 36.3%, and being in a free trade agreement by 10.5% to 13.9%. In all three specifications, the change of the border effect is negative in 2010, which indicates that the border effect became larger (more negative) in 2010 compared to 2006, while it is not statistically different in 2014, such that international trade resurged (interpretation for country pairs with zero distance not sharing a border). The coefficient on the interaction of the border dummy in 2010 and distance is positive and statistically significant showing that the increase in the (negative) border effect in 2010 is smaller for country pairs further from one another in specification 1 and 2. In column 2, the interaction is also significant for 2014 indicating a further decrease for country pairs further form one another. We omit the sector-group interactions in the third column.

[17] Appendix Table A3 shows the results by individual exporting sector. We also find this pattern to be highly consistent over the indicated cuts of the data (not reported).

Table 3. Baseline gravity regression

VARIABLES	(1) Aggregate	(2) Pooled	(3) Interaction
ln Trading Time	-0.245*	-0.356**	-0.486**
	(0.143)	(0.172)	(0.240)
Interactions of ln Trading Time with industry group:			
[Complex GVC excluded group]			
Simple GVC			0.489**
			(0.193)
Homogenous			-0.0348
			(0.253)
Agriculture			-0.0227
			(0.284)
Currency union	0.287***	0.310***	0.303***
	(0.0671)	(0.0846)	(0.0955)
Free Trade Agreement	0.102***	0.134***	0.130**
	(0.0341)	(0.0346)	(0.0602)
BRD 2010	-0.213**	-0.246**	-0.257**
	(0.101)	(0.104)	(0.110)
BRD 2014	-0.210	-0.281	-0.295
	(0.183)	(0.189)	(0.202)
CNTG 2010	0.0476*	0.0561	0.0536
	(0.0249)	(0.0379)	(0.0385)
CNTG 2014	0.0766	0.0927	0.0893
	(0.0561)	(0.0684)	(0.0643)
ln DIST 2010	0.0228**	0.0306***	
	(0.0104)	(0.00966)	
ln DIST 2014	0.0267	0.0428**	
	(0.0185)	(0.0197)	
Constant	13.81***	11.30***	11.29***
	(0.0735)	(0.0882)	(0.0854)
Observations	6,480	111,380	111,380
Exporter(-sector)-year dummies	Yes	Yes	Yes
Importer(-sector)-year dummies	Yes	Yes	Yes
Exporter(-sector)-importer dummies	Yes	Yes	Yes

Note: Results from estimating equation (4). Standard errors clustered at exporter, importer, industry and year dimension (in parenthesis). *** p<0.01, ** p<0.05, * p<0.1. Variables as described in the main text. In column 1, 21 observations are dropped. In columns 2 and 3, 5,638 observations are dropped. Observations are dropped if trade flows between exporter-(sector-)importer are zero in all years (so-called singletons). Interactions of ln DIST 2010 and ln DIST 2014 with industry groups are omitted in column 3.
Source: Author's calculation.

Table 4. Trade elasticities to trading time by exporting industry groups

Industry groups	Coefficients (standard errors)
Complex GVC	-0.486**
	(0.240)
Simple GVC	0.00366
	(0.155)
Homogenous	-0.521***
	(0.174)
Agriculture	-0.508***
	(0.184)
Observations	111,380

Note: Estimates based on column 3 of Table 3. Standard errors obtained using the delta method. *** p<0.01, ** p<0.05, * p<0.1. Source: Author's calculation.

4.2. Value-added effects

Next, we employ the estimated trade elasticities to predict the effect of trade facilitation. We use the point estimates for all sectors within the respective group and set the elasticity to zero for the group of simple GVC manufacturing, for which we obtain an elasticity that is not statistically different from zero. We discuss the net impact in section 4.2.1 and the sectoral distribution in 4.2.2.

4.2.1. Net impact

We start by discussing our results on gross exports for comparison to previous work. The initiated gross-export effect is important as it shows which and by how much sectoral exports are stimulated. Next, we discuss our results on value added, which takes exporters' linkages into account and which is novel in the literature on trade facilitation. Table 5 shows the effect of trade facilitation in our set of African and Asian countries for 5% reductions in export and import time, and for moving to best practices (4 days export time; 6 days import time). We show the results for unilateral (panel A; i.e., reduction of export and import time of the respective country only) and for global (B) improvements (i.e., all countries in the dataset). A 5% reduction equals one day if export time is 20 days, which is a useful benchmark for our set of countries (see Table 2).[18] The 5% scenario illustrates how the studied countries are affected by a uniform change in trade facilitation, so that cross-country gross-export differences are due

[18] We choose five percent rather than one day to use a uniform reduction of trade barriers, which are expressed in percentage changes (see equation 1).

to their export specialisation. When discussing value added, exporters' backward linkages and sectors' forward linkages into other countries' exports matter as well. The best-practice scenario shows the potential maximum effects, which additionally depends on the distance to best practices of the exporting and importing countries. The table shows the predicted change in gross exports, the change in value added in exports (corresponding to terms 1 and 2 in equation 3), and the change in value added in third-country exports (term 3 in equation 3). All values are expressed as percentages of GDP, which is shown as nominal GDP in USD in 2014 in the last column.

Table 5. Net impact of trade facilitation as % of GDP

Country	Gross exports	VA in exports	VA in third-country exports	Gross exports	VA in exports	VA in third-country exports	Nom. GDP 2014 (USD)
Panel A	Unilateral 5% reduction			Unilateral best practices			
Ethiopia	0.06	0.06	0	2.46	2.26	0	47,065
Kenya	0.04	0.04	0	1.23	1.17	0	43,305
Senegal	0.03	0.02	0	0.40	0.33	0	12,673
Bangladesh	0.004	0.003	0	0.13	0.10	0	164,925
China	0.10	0.08	0.002	2.56	1.99	0.09	10,283,984
Indonesia	0.06	0.05	0.001	1.28	0.97	0.02	868,869
India	0.04	0.02	0	0.86	0.47	0	1,994,314
Vietnam	0.30	0.17	0.001	7.33	4.21	0.02	168,731
Panel B	Global 5% reduction			Global best practices			
Ethiopia	0.12	0.11	0.01	3.58	3.31	0.13	47,065
Kenya	0.08	0.08	0.01	1.76	1.66	0.07	43,305
Senegal	0.06	0.05	0.01	0.88	0.72	0.20	12,673
Bangladesh	0.008	0.007	0.002	0.21	0.18	0.03	164,925
China	0.20	0.16	0.03	4.10	3.20	0.46	10,283,984
Indonesia	0.12	0.09	0.04	2.40	1.81	0.63	868,869
India	0.09	0.05	0.02	1.69	0.93	0.26	1,994,314
Vietnam	0.59	0.34	0.07	13.11	7.54	1.13	168,731

Note: Gross-export change obtained using equation 1. VA in exports is the sum of terms 1 and 2 in equation 3, VA in third-country exports is term 3 in equation 3. Scenarios as described in the main text.
Source: Author's calculation.

In section 4.1, we found no evidence that simple GVC manufacturing exports are stimulated by trade facilitation. Countries specialised in these products thus benefit less from trade facilitation. Consistent with that, Bangladesh experiences by far the smallest increase in gross exports as % of GDP (0.004%) from a 5% reduction in its trading time. Ethiopia, Kenya, Senegal, Indonesia and India benefit by about 0.3% to 0.6% of GDP, while China's increase as

% of GDP is about twice as high and Vietnam's even about six times. For any future improvement in trade facilitation, China and Vietnam thus benefit the most, but it is unlikely to be a useful tool for value generation in Bangladesh. We investigate the maximum potential gains by letting our studied countries reduce export and import time to best practices. Moving unilaterally to best practices, especially Vietnam could benefit by an increase of gross exports of 7.3% of GDP. Ethiopia can also benefit to a relatively large degree of 2.5% of GDP, similar to China's potential gain. This is due to Ethiopia's large distance from best practices, as seen in Table 2. Senegal's potential to gain from trade facilitation is relatively small, which is due to its relatively small baseline effect for 5% reductions in trading time and its relatively small distance to best practices (Table 2).

When analysing global improvements in panel B, we additionally take into account that export time not only declines for our set of exporting countries, but also import time for all their importing partner countries. For 5% reductions, the gross-export changes roughly double because also import time now reduces by 5% for all trade partners. For best practices, the difference between unilateral and global improvements depends on the respective distance to best practices of the respective partner countries. For Senegal, Bangladesh, Indonesia, India and Vietnam, the effect also almost doubles but less so for Kenya and Ethiopia. This suggests that the latter trade mostly with countries already relatively close to best practices. As percentage of gross exports of manufacturing and agriculture (as opposed to percentage of GDP), these gross-export changes correspond to 1.3% in Bangladesh, 21% in China, 39% in Ethiopia, 14% in Indonesia, India and Kenya, 9% in Senegal, and 20% in Vietnam. To put these numbers into perspective, we report the results of Oberhofer et al. (2018), which is based on the full-endowment GE following Anderson et al. (2018). Also evaluating global best practices, the authors find that trade from low and middle-income countries to other low and middle-income countries would increase by 19.7% and for trade to high-income countries by 17.6%, which is close to our first-order prediction (the average over our eight countries is 16.5%). It is reassuring that the magnitude of the effects is similar but we cannot disentangle to what extent this is derived from GE effects, which we discuss more generally in section 5. Differences are also due to differently strong trade effects (as discussed in 4.1), as well as due to using one elasticity for all traded goods in their study while we obtain heterogeneous effects by sector group.

Our first major innovation compared to previous approaches to evaluate trade facilitation is to investigate value added in exports, taking linkages into account. This sum of the first two terms in equation 3 shows how much value added is generated domestically in producing the change in gross exports. This importantly takes into account that exports typically require imports and thus that the net impact in value-added terms is smaller than the gross impact. The size of this difference depends on the import propensity of direct and indirect exporters, which partly relates to the type of exported products. Agriculture, for example, typically uses relatively few foreign inputs, while machinery relies relatively heavily on imported inputs (e.g., Pahl and Timmer, 2019). For this reason, the difference between gross exports and value added in exports is relatively small in the set of African countries that benefit mostly from rising agricultural exports (see below). In Kenya, for example, it is only about 5% less than gross exports in the cases of best practices. The difference is indeed sizeable in China, Indonesia, India and Vietnam, where the valued-added effect is only 55% to 78% of the gross-export effect. Instead of 13.1% of GDP in terms of gross exports, Vietnam thus only generates about 7.5% of GDP in value-added in exports for global best practices. India and Senegal benefit to a relatively similar degree in value-added terms, while India's potential benefit appeared to be much larger for gross exports.

The second major difference of our evaluation of the net impact is the inclusion of third-country effects. These are trade effects that occur in country *i* induced by trade flows between *j* and *k*. For example, this can include value added generated in the chemicals sector in country *i*, which is not stimulated by reduced trading time (see 4.1) but might be required to produce stimulated rubber exports from *j* to *k*. Third-country effects are thus particularly important with global improvements, but they might also occur with unilateral improvements if there is large back and forth trade, such that countries export intermediates that are elsewhere assembled and return as finalised goods (e.g., USA with Mexico; China in our sample, see Table 5). In general, countries with large third-country effects are relatively far upstream in value chains with strong forward linkages. As big suppliers of primary products, one might expect the African countries to benefit relatively largely from such third-country effects. Yet, for this effect to materialise, it is important whether the downstream sectors are indeed stimulated. Especially Ethiopia and Kenya have relatively small value-added gains through third-country export growth, making up of less than 4% of the total value-added gain and only 0.1% of GDP in the case of global best practices (also small for Bangladesh). In contrast, the remaining countries have value added growth through third-country exports of more than 10% of the total value-added gain, going up to 25% in Indonesia. Relative to GDP, this matters in particular in Vietnam, which may generate more than 1% of GDP through stimulated exports in other countries, but also China and Indonesia generate a relatively large share of GDP.

Including third-country effects is thus important in the evaluation. While sourcing of foreign intermediates to produce exports lowers the net impact in value-added terms, we find that for some countries, taking third-country effects into account strongly counteracts this. In Senegal for example, we find that the net impact is ultimately higher in value-added terms than in gross export terms. Despite also being suppliers of primary goods, Kenya and Ethiopia lack strong forward linkages into exports that are stimulated by trade facilitation and thereby miss out on potential benefits that accrue to other countries in our sample. For Kenya and Ethiopia, it is important to identify trade policies that stimulate products to which they have strong forward linkages, and to identify ways to link into exports that are stimulated by trade facilitation.[19]

Overall, we find that relatively large potential gains are possible in Vietnam (8.6% of GDP), China (3.6%), Ethiopia (3.4%) and Indonesia (2.4%). In Kenya (1.7%), the potential gains are moderate. They are relatively small in India (1.2%) and Senegal (0.9%) and particularly small in Bangladesh (0.2%).

4.2.2. Sectoral structure

In this section, we discuss the sectoral value-added impacts of trade facilitation for global improvements to best practices. This is particularly important if interested in whether such trade policies foster structural change, which is a key discussion for development in many lower income countries (e.g., Rodrik, 2016). The sectoral impacts depend firstly on which trade flows are stimulated and by how much they are stimulated by trade facilitation. This depends on the initial sectoral bilateral export flows, and on the improvement of trade facilitation in the respective country pair. Secondly, it depends on the backward linkages of the exporters. Broadly, it is typically found that agriculture has relatively fewer backward linkages than manufacturing (e.g., Johnson and Noguera, 2017). Yet, there is heterogeneity whether these are into foreign or domestic sectors, and which domestic sectors link to exporters. Thirdly, we also track the sectoral structure of value added generated through third-countries' exports, which has not yet been explored. Broadly speaking, as agricultural exports tend to have less backward linkages, third-country gains tend to derive from integration into manufacturing exports. It is likely to be country-specific through which type of activities countries contribute to those third-country exports.

[19] As a robustness test, we also show the best-practice results of Table 5 with trade elasticities estimated at the level of each exporting sector in appendix Table A4. The conclusions are similar and the magnitude of the effects as well.

Table 6 shows the sectoral shares of the induced changes. We group all sectors in the economy into the three manufacturing groups, agriculture, non-manufacturing industry (mining, electricity, construction), business services, and other services. We split business services from other services as these are typically seen as productive activities that can stimulate economic development (e.g., Lavopa and Szirmai, 2018). In the table, we show the sectoral shares of gross exports, and of the sum of value added (the total value-added effects as shown in equation 3). The sectoral shares of gross exports show by how much respective trade flows are stimulated, and the value-added shares take linkages into account.

Table 6. Sectoral structure (%) induced by global improvements to best practices

		Agri-culture	Non-mfg industry	Simple GVC MFG	Homo-genous MFG	Complex GVC MFG	Other services	Business services
Ethiopia	GX	93.1	0	0	6.7	0.2	0	0
	VA	93.3	0.2	0.2	1.5	0.1	4.2	0.5
Kenya	GX	98.8	0	0	1.0	0.2	0	0
	VA	94.2	0.7	0.7	1.6	0.0	2.4	0.4
Senegal	GX	56.3	0	0	40.0	3.6	0	0
	VA	43.3	4.9	1.8	6.6	1.6	35.4	6.4
Bangladesh	GX	48.7	0	0	20.0	31.3	0	0
	VA	41.4	5.5	6.5	11.0	9.4	19.0	7.2
China	GX	1.0	0	0	23.2	75.8	0	0
	VA	4.3	11.7	7.2	17.1	30.0	16.9	12.9
Indonesia	GX	5.9	0	0	64.6	29.5	0	0
	VA	12.6	23.3	5.2	28.5	12.7	13.1	4.4
India	GX	11.1	0	0	62.8	26.2	0	0
	VA	16.8	13.3	5.3	20.6	12.2	21.4	10.4
Vietnam	GX	19.2	0	0	24.8	55.9	0	0
	VA	19.1	10.5	2.9	14.2	42.7	8.9	1.7

Note: GX is gross exports, VA is the sum of generated value added, as calculated in equation 3.
Source: Author's calculation.

In Kenya and Ethiopia, most of stimulated gross exports are in agriculture with very minor stimulation in homogenous manufacturing. In Senegal, homogenous manufacturing makes up of 40% and complex GVC manufacturing of 4% besides agriculture. Also in India and Indonesia, homogenous manufacturing is strongly stimulated with relatively less complex GVC manufacturing and agriculture. In China and Vietnam, complex GVC manufacturing is relatively strongly stimulated. Taking account of the backward linkages of those sector and the value-added effects of third-country exports, we obtain the value-added effects shown in Table 6. Overall, manufacturing sectors are relatively less stimulated in value-added terms because of their backward linkages into other domestic and foreign sectors, while agriculture shows a similar or higher share. In Senegal, 40% of stimulated gross exports are homogenous manufacturing but only 7% in value-added terms, but 35% in other services. This shows strong backward linkages into services contributing to manufacturing exports. India and Indonesia also experience a relatively large increase in homogeneous manufacturing, which is substantially lower in value-added terms. Yet, non-manufacturing industry has a relatively large share and not other services. China and India stand out as they have a relatively large share of business services stimulated by trade facilitation.

In appendix Table A5, we explore this heterogeneity in more detail and show sectoral shares of value added in direct, indirect and third-country effects. Column 2 of Table A5 shows the structure in direct exports, that is, how much sectors contribute to their own sectoral exports. This confirms relatively less backward linkages in agriculture than in manufacturing. Yet, Vietnam for example, adds a relatively large share of complex GVC manufacturing value added in direct exports as it appears that these sectors contribute a lot of value directly to their exports. Backward linkages to domestic sectors are shown in column 3 of Table A5. In the African countries, the overwhelming majority of linkages to their exporting (manufacturing) firms are in other services, which make up more than 75% in all three countries in indirect sector exports. Most of these activities stem from wholesale trade (not separately reported). In the Asian countries, the indirectly contributing sectors are to a larger extent manufacturing and business services. Hence, backward linkages of exporting firms tend to stimulate other relatively more productive activities in the Asian countries but mostly services in the African countries. In column 5 of Table A5, we show the sectoral structure of third-country effects, which mostly derive from stimulated homogenous and complex GVC manufacturing. Interestingly, the structure of those effects tends to be more equally spread across sectors in all our countries. However, we find that it includes relatively large shares of relatively less productive sectors in Ethiopia (68% agriculture) and in Senegal (54% other services). In Kenya, the third-country value-added effects are made up of 45% of manufacturing industries. In the Asian countries, these forward-linked sectors tend to be mostly manufacturing and business services (except Indonesia with a high share of mining). Overall, stimulation of these forward-linked sectors seems to provide value generation in relatively more productive sectors than value added in exports (column 2). Third-country linkages are thus not only important because they increase the net impact of trade facilitation, as discussed in 4.2.1, but also because they tend to provide opportunities to shift into manufacturing and business services.

5. Discussion

Our results are based on implementation of equations 1 to 3, which allows us to obtain the first-order value-added effects of changes in trade facilitation. In this section, we discuss possible GE effects that our approach does not account for. In 5.1, we discuss trade diversion and value-chain adjustments, and in 5.2, we provide a first empirical exploration of observed value-chain adjustments.

5.1. Possible general-equilibrium effects

We discuss two potential sources of GE effects: trade diversion, and value-chain adjustments. The former reflects the traditional GE effect in the gravity literature. The key characteristic is that *relative* trade costs between *i* and *j* matter in GE. That is, it does not only matter whether country-*i* goods become cheaper (due to bilateral trade costs) but whether they become cheaper relative to other source countries. For example, if countries *i* and *j* form a trade agreement, the decrease of bilateral trade costs increases trade flows. Yet moreover, this leads to trade diversion, because all other countries become relatively more expensive, such that countries *i* and *j* trade relatively less with those countries. While not implemented empirically, Vandenbussche et al. (2019) provide a derivation of this additional term in the comparative statics of their theoretical model, which depicts the change in relative trade costs through the proportionate change in the so-called multilateral resistance terms. We do not attempt to include these effects from trade diversion and only provide empirical results on the first-order effects. In our case of trade facilitation, however, one might argue that trade diversion is only expected to play a relatively small role. In the bulk of our results, we focus on global improvements in trade facilitation. As all countries reduce trade barriers in these scenarios, changes in relative trade costs are expected to be relatively small (but still present), as, for example, compared to evaluating a bilateral trade agreement. This is in particular the case for our global 5% scenario in which all countries improve by the same degree. Given that trade facilitation is supported by supranational organisations, such as through the WTO's trade facilitation agreement, strong patterns of trade diversion are unlikely to be the outcome of implemented trade facilitation policies, and therefore empirically less relevant for the evaluation.

A recently widely-used empirical approach to include these GE effects is to follow Anderson et al. (2018). This approach is based on the empirical property that the fixed effects of a PPML estimation are equal to the multilateral resistance terms, which was shown by Arvis and Shepherd (2013) and Fally (2015). This allows for a counterfactual analysis based on changes in the trade cost vectors, with empirical estimation of (counterfactual) multilateral resistance terms, thereby accounting for trade diversion (so-called conditional GE in Anderson et al., 2018). We do not follow this approach because it does not lend itself in a straight-forward manner to studying production fragmentation and value-added in exports since it does not incorporate input-output linkages. With respect to trade facilitation (also measured by trading time), Oberhofer et al. (2018) use this framework to assess the GE effects of trade facilitation at the country level based on gross exports. The authors do not report conditional GE results, but so-called full-endowment GE results. As a next step from conditional GE, Anderson et al.'s (2018) approach models how changes in trade costs affect prices and thereby output and expenditure, which again impacts trade flows and multilateral resistance terms. In section 4, we found that the size difference between those full-endowment GE trade effects and our first-order results are relatively small.

There is a second channel of potential GE effects, which Vandenbussche et al.'s (2019) model does not take account of because it is based on constant technologies, that is, constant L and v. The endogenous reorganisation of global value chains is a new GE effect in the literature and only attempted by a small set of recent studies (e.g., Antras and de Gortari, 2019; Johnson and Moxnes, 2019; Yi, 2003; 2010). An important difference to more traditional theoretical models is the introduction of so-called multistage intermediate input production, while earlier studies use so-called roundabout production.[20] Roundabout production means that final and intermediate goods are produced with the same production technology and the sector's output may also be both intermediate or final good.[21] Multistage production, however, requires that output of one stage is only used as an input into another stage, and both stages have distinct production technologies. As argued by Johnson and Moxnes (2019), multistage cross-country production implies that trade costs are paid multiple times, and that ad valorem trade costs are relatively higher in production stages further downstream because the output value increases from stage to stage.[22] Based on this multistage production setup, the authors obtain the result that trade elasticities increase with falling levels of trade costs. The authors argue that low trade costs make cross-country multistage production more likely (that is, it is possible to fragment) and thereby increase the benefit of further reductions of trade costs. They further argue that this

[20] Multistage production, however, has a much longer history in trade theories, going back at least to Dixit and Grossman (1982).
[21] This is also the structure in input-output tables. For a discussion on these assumption in input-output tables, see de Gortari (2019).
[22] For an empirical application, see Muradov (2017).

does not only have implications for world trade elasticities (as argued by Yi, 2003; 2010) but they obtain heterogeneous trade elasticities of bilateral trade to bilateral trade costs, varying by country pairs and trade-cost levels. Trade between country pairs with already low trade costs will thus be stimulated more by the same reduction in trade costs than between pairs with high trade costs. The traditional gravity equation as used here (section 2.2) estimates average elasticities of bilateral trade to trade costs without heterogeneity by pair and level of trade costs. For our results, their argument suggests that especially the low-income countries with relatively high trading time (starting from a high level of bilateral trade costs) may benefit relatively less than suggested by the estimation and vice versa.

However, there is also a literature that argues that GVC trade may in fact be relatively less sensitive to trade cost changes once established. Antras (2019), for example, argues that trade within GVCs might be relatively sticky due to substantial relationship-specific investments or trade of intangibles between participating firms. In this case, we would expect relatively minor value-chain adjustments, such that the considerations are less relevant for the short and medium run.

5.2. Exploration of value-chain adjustments

For a first exploration of such value-chain adjustments, we investigate changes in gross exports and value-added in exports since 2006. That is, we predict the change of gross exports and value-added with 2006 exports as the base (in equation 1). We predict value-added changes for global improvements in trade facilitation as observed between 2006 to 2014 first with the input-output structure (L) and value-added to gross-output coefficients (v) of 2006. Secondly, we repeat the analysis but base it on the 2014 input-output structure and value-added to gross-output coefficients. In the first case, we predict the changes based on the value-chain configurations at the time of measurement of the exports, and in the second case, we predict the changes based on the value-chain configurations eight years later (the last year in our dataset). Hence, we only vary the underlying production structures in the two scenarios but the first-order export changes are the same. It answers to what extent backward-linked value chains of stimulated exporters have adjusted and thereby affect value-added generation. The adjustments in production structures observed, however, are due to the variation of all factors that determine those production structures.

The results of these predictions are shown in Table 7 for value added in exports and for value added in third-country exports. It also shows the ratios of predicted value-added changes using the 2014 structure to the changes using the 2006 structure. The prediction on value-added in exports shows relatively small differences across both structures. The largest relative difference is observed for Vietnam for which the prediction of value-added in exports is 13% higher using the 2014 structure. This indicates that the domestic input-output structure and the value-added to gross-output ratios have not adjusted substantially. This is perhaps no surprise as countries typically reduced importing to exporting through the crisis of 2008/2009 and on average just returned to pre-crisis levels afterwards (e.g., Pahl and Timmer, 2019). Yet, the predictions of value-added in third-country exports are indeed different. The differences are quite substantial for Ethiopia and Senegal, which over the years seem to have integrated much more into the world economy through (relevant) forward linkages. Changes are also large for China and Vietnam, still meaningful for India and Kenya and do not change much for Bangladesh and Indonesia. Hence, value-chain adjustments do play a role in investigating third-country effects, as it appears that our set of countries tends to increase integration through forward linkages. Considering our results in the previous sections on third-country effects, this suggests that they might potentially be understated for the considered set of countries if this trend of increasing integration into the world economy continues. This suggests potentially larger net gains and more stimulation of manufacturing (as the third-country effects tend to generate value added in manufacturing and business services, see Table A6).

As discussed in section 5.1, Johnson and Moxnes (2019) argue that low trade costs allow countries to engage in fragmented production, and further that additional reductions of trade costs are more beneficial when trade costs are already low. Interpreting the results through this lens, we expect large increases in third-country effects for countries with already low bilateral trade costs to all relevant trade partners and further moderate reductions of trade costs, or for countries with major reductions of trade costs even with relatively high initial bilateral trade costs to the relevant trade partners. The two countries with the largest increases in third-country linkages in this case are Ethiopia and Senegal. We have no way of directly investigating the role of trade facilitation in this reconfiguration in a counterfactual analysis, as we only observe the value-chain adjustments that are due to the variation of all relevant trade costs. Recalling Table 2, however, we see that Senegal has started off with relatively low export and import time and it further improved substantially. One may thus argue that trade facilitation has possibly contributed to the observed reconfiguration. For Ethiopia, however, we observe that it started off with very high levels of trading time and only made minor improvements. This would suggest that other factors must have been more important in inducing the observed value-chain adjustments. To make a prediction about potential additional GE effects, we would thus expect that countries can retrieve additional gains through forward linkages depending on the initial level and the subsequent fall of bilateral trade costs to the main trading partners.

The relatively large changes in the third-country effects and the relatively large cross-country differences suggest that it is an important and fruitful avenue for future research to allow for counterfactual analyses of value-chain reconfigurations due to single trade policies, such as trade facilitation.

Table 7. Net impacts of trade facilitation using alterative baseline structures: global changes of observed changes in trading time

		2006 structure		2014 structure		Ratio (2014/2006)	
Country	Gross exports	VA in exports	VA in third-country exports	VA in exports	VA in third-country exports	VA in exports	VA in third-country exports
Ethiopia	9	8	1	8	4	1.00	2.91
Kenya	56	50	2	52	2	1.04	1.11
Senegal	21	19	1	19	2	1.00	2.11
Bangladesh	59	49	5	49	4	1.00	0.98
China	10,154	7,157	2,405	7,906	4,958	1.10	2.06
Indonesia	2,539	2,029	511	1,994	499	0.98	0.98
India	5,095	2,930	396	2,812	449	0.96	1.13
Vietnam	367	196	86	221	157	1.13	1.83

Note: Gross exports change obtained using equation 1. VA in exports is the sum of terms 1 and 2 in equation 3, VA in third-country exports is term 3 in equation 3. All values in 2014 million USD. Scenarios as described in the main text.

Source: Author's calculation.

6. Conclusion

Trade facilitation is often considered to be an important avenue for developing countries to increase their opportunities to export. The popularity of such measures (e.g., WTO's trade facilitation agreement) calls for an evaluation of the effects of implementation. There is hardly doubt that reducing trade barriers is beneficial for the implementing countries but since implementation is typically costly, it is important to form expectations. In this paper, we aim to contribute to the literature on trade facilitation by providing predictions for lower income countries, taking the global fragmentation of production into account.

The novelty lies in translating trade elasticities into value-added terms making use of the cross-country, cross-sectoral input-output structure of the world economy. We obtain trade elasticities of trading time based on a fully-specified sectoral structural gravity equation in the spirit of

Yotov et al. (2016). Following Vandenbussche et al. (2019), we use those elasticities to obtain sectoral value-added effects. We decompose these effects into direct, indirect and third-country export effects. Sectoral value added thus derives from exports by the sector itself (direct effect), from indirect exports via other sectors of the same country and from linkages into other countries' stimulated exports.

We find that the potential benefits of trade facilitation are relatively sizeable in our set of low-income African countries, and even more so in some of the low and lower-middle income Asian countries. Yet, we also find that the African countries benefit relatively less from stimulated third-country exports. Despite Kenya's and Ethiopia's specialisation in primary products, which potentially link into value chains further downstream, they do not appear to be linked into value chains that are stimulated by trade facilitation. This raises the important issue that there might be an additional burden to specialisation in products that are not stimulated by trade policies. Exporters of the respective products will face no increase in exports but also all indirect (foreign) suppliers will miss out on a potential gain. In the case of trade facilitation, this is relevant for exporters of and suppliers to food manufacturing and textiles, which is a typical specialisation pattern for developing countries. In terms of sectoral structure, we find that it is mostly the primary sectors and relatively low-productivity services sectors (e.g., wholesale trade) that are stimulated through trade facilitation in the three African countries, while typically more manufacturing and business services in the Asian countries.

These findings are in contrast to predictions obtained from gross exports. Firstly, the net impact of gross exports is overstated compared to value-added effects, and particularly so in manufacturing trade (due to foreign sourcing). Secondly, the analysis based on gross exports does not take third-country exports into account. These can be sizeable and further particularly set the gains in some of the Asian countries apart from Ethiopia and Kenya. Thirdly, gross exports do not take linkages into account and thereby omit this country heterogeneity in sectoral structure.

As discussed in section 5, a caveat of our approach and a major avenue for future research is to model how global value chains adjust with changing trade costs (in the spirit of Johnson and Moxnes, 2019). Our approach takes the world input-output structure as fixed and does not allow for adjustments. In one extension of the main results, we explored how the empirically observed changes affect our main predictions. While the changes are not large enough to alter our main conclusions, it suggests that these adjustments are indeed important over the longer run. Similarly, we did not attempt to incorporate GE effects due to trade diversion, which we argued are expected to be relatively small in our scenarios as we study global improvement in trade facilitation, such that relative trade costs change to a relatively small degree. Nonetheless, a further step to fully understand long-run equilibrium effects is to incorporate export effects due to trade diversion and value-chain adjustments.

A second caveat is more closely related to investigating trade facilitation. Current measures of trade facilitation are only available at the country level. We rely on the most widely used measure but there is clearly scope for improvement. In particular, this measure only speaks to standardised cargo and does not take any industry heterogeneity into account. It is reassuring that our sector-level results are broadly consistent with Hummels (2001) using a different measure of time costs. Besides, the only source of heterogeneity in our approach is the exporting sector. Micro-level research has shown that there are various sources of heterogeneity in trading time (e.g., Carballo et al., 2014; Feenstra and Ma, 2014; Hayakawa et al., 2019; Martincus et al., 2015). The micro literature further raises the issue that aggregate measures are difficult to interpret because they are a combination of actual processing times and optimally chosen times by the exporting firms (e.g., Carballo et al., 2016). Hence, a stronger link between micro-level findings and macro evaluations would generally prove beneficial. However, an open avenue for investigation in the micro and macro literature is when trading time matters most with respect to global value chains. We make the argument that specific products are more likely to be traded within GVCs and thereby more sensitive to time. This is clearly a broad classification but more detail is also not yet added by micro data because more information on the trade relationships would be required. Currently, micro studies are able to exploit variation at the firm level (e.g., firm size, sector) and type of product (e.g., homogenous, intermediate) but information on the trading partner of the exporting firm is typically scarce. To understand dynamics in global value chains, it would be particularly interesting to add information on the buying firm, on the final market to which the final good is ultimately sold, and even on the type of firms in the entire value chain (e.g., the lead firm). We believe that this is a fruitful avenue for future research that helps understanding trade and trade costs with global production fragmentation.

Declarations

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Appendix. Additional tables

Table A1. Trade elasticities to trading time by sector groups for alternative specifications

Industry groups	4-year periods with tariffs	4-year periods of intermediates	3-year periods
	Coefficients (standard errors)	Coefficients (standard errors)	Coefficients (standard errors)
Complex GVC	-0.489**	-0.514	-0.745***
	(0.233)	(0.379)	(0.214)
Simple GVC	0.000173	0.0959	-0.164
	(0.156)	(0.175)	(0.192)
Homogenous	-0.523***	-0.573***	-0.645***
	(0.176)	(0.188)	(0.247)
Agriculture	-0.522***	-0.486***	-0.274
	(0.184)	(0.136)	(0.168)
Observations	109,734	110,466	111,350

Note: Estimates based on regressions as column 3 of Table 3. Standard errors obtained using the delta method. *** p<0.01, ** p<0.05, * p<0.1.
Source: Author's calculation.

Table A2. Trade elasticities to trading time for group-level regressions for alternative specifications

		Complex GVC	Simple GVC	Homogenous	Agriculture
4-year periods	Coefficient	-0.474**	-0.00745	-0.502***	-0.527*
	Standard error	(0.236)	(0.131)	(0.165)	(0.276)
	Obs.	30,815	37,479	36,702	6,384
4-year periods with tariffs	Coefficient	-0.462**	-0.00712	-0.502***	-0.609***
	Standard error	(0.212)	(0.129)	(0.164)	(0.229)
	Obs.	30,404	36,876	36,208	6,246
4-year periods of intermediates	Coefficient	-0.502	0.0737	-0.549***	-0.531**
	Standard error	(0.385)	(0.126)	(0.184)	(0.226)
	Obs.	30,507	37,017	36,600	6,342
3-year periods	Coefficient	-0.756***	-0.170	-0.618**	-0.352**
	Standard error	(0.222)	(0.163)	(0.249)	(0.167)
	Obs.	30,778	37,440	36,760	6,372

Note: All coefficients represent the trade elasticities pooled over respective group of sectors, with all dependent variables varying by sector group.
Source: Author's calculation.

Table A3. Trade elasticities to trading time by exporting sector

	Industry	Elasticity	SE
Simple GVC	FOOD (10t12)	-0.00642	(0.191)
	TEXT (13t15)	0.000970	(0.292)
	PAPER (17t18)	-0.0234	(0.331)
	CHEM (20)	-0.0912	(0.296)
	PHARMA (21)	0.0572	(0.516)
	OTH MFG (31t33)	-0.133	(0.242)
Homogenous	WOOD (16)	-0.643**	(0.272)
	PETRO (19)	-0.0661	(0.366)
	RUBBER (22)	-0.402*	(0.242)
	MINERAL (23)	0.113	(0.295)
	BAS METAL (24)	-0.936***	(0.345)
	FAB METAL (25)	-0.546***	(0.197)
Complex GVC	COMP (26)	-0.541**	(0.276)
	ELEC (27)	-0.733**	(0.304)
	MACH (28)	-0.663**	(0.311)
	MOTOR (29)	0.305	(0.320)
	TRANS (30)	-1.995***	(0.403)
Agriculture	AGRI (A)	-0.504*	(0.288)

Note: Estimates based in the spirit of equation 4 but with interaction terms for each sector individually. Standard errors obtained using the delta method. *** p<0.01, ** p<0.05, * p<0.1.
Source: Author's calculation.

Table A4. Net impact of trade facilitation to global best practices as % of GDP, using sector-specific trade elasticities.

Country	Gross exports	VA in exports	VA in third-country exports	Nom. GDP (USD)
Ethiopia	3.73	3.37	0.14	47,065
Kenya	1.75	1.65	0.07	43,305
Senegal	1.18	0.93	0.24	12,673
Bangladesh	0.32	0.26	0.03	164,925
China	4.90	3.82	0.49	10,283,984
Indonesia	2.32	1.69	0.62	868,869
India	1.43	0.90	0.27	1,994,314
Vietnam	14.90	8.40	1.18	168,731

Note: Gross exports change obtained using equation 1, using trade elasticities as shown in Table A3. VA in exports is the sum of terms 1 and 2 in equation 3, VA in third-country exports is term 3 in equation 3. All values in 2014 million USD. Scenarios as described in the main text.

Source: Author's calculation.

Table A5. Sectoral structure impacts of trade facilitation, detailed results

Country	Industry group	Gross Exports	VA in direct exports	VA in indirect sector exports	VA in third-country exports	Sum of VA effects
Ethiopia	Agriculture	93.1	98.8	3.6	74.1	93.3
	Non-mfg industry	0.0	0.0	3.1	2.4	0.2
	Simple GVC	0.0	0.0	3.9	1.2	0.2
	Homogenous	6.7	1.2	2.7	7.8	1.5
	Complex GVC	0.2	0.1	0.1	0.1	0.1
	Services	0.0	0.0	77.1	12.8	4.2
	Business services	0.0	0.0	9.6	1.6	0.5
Kenya	Agriculture	98.8	99.5	0.1	34.1	94.2
	Non-mfg industry	0.0	0.0	5.7	13.1	0.7
	Simple GVC	0.0	0.0	1.8	15.7	0.7
	Homogenous	1.0	0.5	4.8	24.3	1.6
	Complex GVC	0.2	0.0	0.0	0.1	0.0
	Services	0.0	0.0	76.8	10.4	2.4
	Business services	0.0	0.0	10.8	2.2	0.4
Senegal	Agriculture	56.3	89.2	0.9	3.4	43.3
	Non-mfg industry	0.0	0.0	4.0	16.7	4.9
	Simple GVC	0.0	0.0	1.9	5.4	1.8
	Homogenous	40.0	8.5	0.4	11.1	6.6
	Complex GVC	3.6	2.4	0.6	1.5	1.6
	Services	0.0	0.0	78.2	52.2	35.4
	Business services	0.0	0.0	14.0	9.8	6.4

Note: Gross exports change obtained using equation 1. VA in exports is the sum of terms 1 and 2 in equation 3, VA in direct exports is term 1 in equation 3, VA in indirect exports is term 2 in equation 3, VA in third-country exports is term 3 in equation 3. Sum of VA effect is the sum of terms 1 to 3 in equation 3. Totals in 2014 million USD. Scenarios as described in the main text.
Source: Author's calculation.

Table A5 (continued). Sectoral structure impacts of trade facilitation, detailed results

Country	Industry group	Gross Exports	VA in direct exports	VA in indirect sector exports	VA in third-country exports	Sum of VA effects
Bangladesh	Agriculture	48.7	72.0	2.2	11.3	41.4
	Non-mfg industry	0.0	0.0	11.4	13.6	5.5
	Simple GVC	0.0	0.0	6.6	31.1	6.5
	Homogenous	20.0	12.3	10.8	6.5	11.0
	Complex GVC	31.3	15.7	0.3	5.2	9.4
	Services	0.0	0.0	49.7	23.6	19.0
	Business services	0.0	0.0	19.0	8.7	7.2
China	Agriculture	1.0	2.7	5.1	4.2	4.3
	Non-mfg industry	0.0	0.0	17.5	12.3	11.7
	Simple GVC	0.0	0.0	10.1	10.5	7.2
	Homogenous	23.2	21.7	15.2	15.1	17.1
	Complex GVC	75.8	75.6	8.2	24.1	30.0
	Services	0.0	0.0	25.1	18.5	16.9
	Business services	0.0	0.0	18.8	15.3	12.9
Indonesia	Agriculture	5.9	13.2	16.3	6.7	12.6
	Non-mfg industry	0.0	0.0	33.1	44.3	23.3
	Simple GVC	0.0	0.0	6.7	11.0	5.2
	Homogenous	64.6	60.7	3.8	15.3	28.5
	Complex GVC	29.5	26.1	2.9	6.5	12.7
	Services	0.0	0.0	28.6	11.1	13.1
	Business services	0.0	0.0	8.7	5.1	4.4
India	Agriculture	11.1	37.5	3.9	6.2	16.8
	Non-mfg industry	0.0	0.0	25.2	13.2	13.3
	Simple GVC	0.0	0.0	5.6	13.6	5.3
	Homogenous	62.8	38.4	7.9	14.5	20.6
	Complex GVC	26.2	24.1	3.6	8.1	12.2
	Services	0.0	0.0	38.3	26.0	21.4
	Business services	0.0	0.0	15.5	18.3	10.4
Vietnam	Agriculture	19.2	24.6	11.6	6.4	19.1
	Non-mfg industry	0.0	0.0	28.0	28.4	10.5
	Simple GVC	0.0	0.0	9.2	5.1	2.9
	Homogenous	24.8	15.0	12.7	13.1	14.2
	Complex GVC	55.9	60.4	0.2	36.6	42.7
	Services	0.0	0.0	32.2	8.4	8.9
	Business services	0.0	0.0	6.1	1.9	1.7

Note: Gross exports change obtained using equation 1. VA in exports is the sum of terms 1 and 2 in equation 3, VA in direct exports is term 1 in equation 3, VA in indirect exports is term 2 in equation 3, VA in third-country exports is term 3 in equation 3. Sum of VA effect is the sum of terms 1 to 3 in equation 3. Totals in 2014 million USD. Scenarios as described in the main text.
Source: Author's calculation.