Export Performance and Trade Facilitation Reform:

Hard and Soft Infrastructure

Alberto Portugal-Perez*

John S. Wilson**

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* Economist, The World Bank, 1818 H Street NW, Washington, DC 20433. Telephone: 202-473-7428, fax: 202-473-1159, email: aportugal@worldbank.org.
** Lead Economist, The World Bank, 1818 H Street NW, Washington, DC 20433. Telephone: 202-473-7428, fax: 202-473-1159, email: jswilson@worldbank.org

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ABSTRACT

We estimate the impact of aggregate indicators of “soft” and “hard” infrastructure on the export performance of developing countries. We derive four new indicators for more than 100 countries over the period 2004-07. Estimates show that trade facilitation reforms do improve the export performance of developing countries. This is particularly true with investment in physical infrastructure and regulatory reform to improve the business environment. The findings provide evidence that the marginal effect of the quality of physical infrastructure improvement on exports appears to be decreasing in per capita income. In contrast, the impact of information and communications technology on exports appears increasingly important the richer a country becomes. We also find statistical evidence on the complementarity between hard infrastructure and soft infrastructure, as captured by our indicators. Finally, drawing on estimates, we compute illustrative ad-valorem equivalents of improving each indicator halfway to the level of the top performer in the region.

Keywords: Export performance, trade facilitation, soft and hard infrastructure, gravity model, developing countries, Sub-Saharan Africa.

JEL Classifications F10, F17

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1. INTRODUCTION

In an international trade environment of declining tariffs, trade facilitation—broadly defined as the set of policies aiming at reducing export and import costs—has been in the spotlight policy fora as the next key option to reduce trade costs in developing countries. The relationship between export performance and trade facilitation is complex, not only because a country's trade flows may change through its own trade facilitation reforms and through its trading partners' reforms, but also because of the multi-dimensionality of trade facilitation.

In a narrow sense, trade facilitation is associated with the reduction of on-the-border transaction costs other than tariff cuts, which essentially involves the simplification and standardization of customs formalities and administrative procedures related to international trade. The current WTO negotiations on trade facilitation are mainly linked to this dimension of border (or customs) facilitation. In a broader sense, trade facilitation not only includes at-the-border issues, but also beyond-the-border issues, dealing for instance with the business environment, the quality of infrastructure, transparency, and domestic regulations. All of these factors have an impact on export performance through the cost channel. Trade facilitation measures can be undertaken along two dimensions: a "hard" dimension related to tangible infrastructure such as roads, ports, highways, telecommunications, as well as a "soft" dimension related to transparency, customs management, the business environment, and other institutional aspects that are intangible.

A myriad of indicators related to different aspects of trade facilitation at the country level and with extensive geographic coverage have recently been collected by different organizations, and used in empirical research to estimate their impact on trade.[1] From an econometric point of view, including variables related to trade facilitation, measuring similar aspects on the right-hand side of a model, such as a gravity specification, can be conducive to multicolinearity. A way of circumventing multicolinearity is to reduce the dimension of the data by aggregating highly correlated indicators into a single indicator.

We construct four new aggregate indicators related to trade facilitation from a wide range of primary indicators using factor analysis, a statistical modeling technique that explains the correlation among a set of observed variables through an unobserved "common factor." It not only helps to circumvent multicolinearity by reducing the dimensions of the data, it is a more rigorous and less arbitrary procedure for deriving an "aggregate" indicator compared with averaging out primary indicators. Although similar to principal components method, factor analysis has an underlying analytical model. It assumes that the observed primary indicators are determined by unobserved factors (the aggregate indicators computed by the procedure) . The new aggregate indicators contain the information of a wider range of individual indicators than previous studies, and focus on factors that are related to the "hard" or "soft" dimension of trade facilitation.

Two of the four indicators are closely related to the "hard" dimension of trade facilitation: (i) physical infrastructure and (ii) information and communications technology (ICT). The other two indicators are more closely linked to the "soft" dimension: (iii) border and transport efficiency and (iv) the business and regulatory environment. The indicators are derived for 101 countries over the period 2004-07, a greater coverage than previous indicators and a more recent one. The indicators are derived from a pool of 20 primary indicators collected from different sources: Doing Business (DB), World Development Indicators (WDI), World Economic Forum (WEF), and Transparency International (TI).

We assess the impact of different aspects related to trade facilitation, as measured by our indicators, on export performance by estimating a gravity model. Our study also departs from most previous papers in at least three additional ways. First, we cover more data and dimensions regarding hard and soft-dimensions of infrastructure. Second, as there have been recent contributions to the econometric estimates of gravity-type of models[2], we use the latest econometric techniques to estimate our model. Indeed, we implement a two-stage sample selection model (Heckman 1979) a la Helpman, Melitz, and Rubinstein (henceforth, HMR) (2008) to deal with a potential bias due to unobserved firm-level heterogeneity and a sample selection bias due to country-pairs without trade (in at least one direction)[3]. The two-stage approach allows assessment of export performance along the intensive margin and extensive margin. Our results suggest that trade facilitation reforms could improve the export performance of developing countries at the extensive and intensive margin, especially investment in physical infrastructure and regulatory reform to improve the business environment. We also attempt to deal with the potential reverse causality of exports to trade facilitation by restricting the analysis to exports of new products, as trade in new goods cannot affect investment in 'hard infrastructure' or institutional reform. We also take into account omitted multilateral resistance effects following a procedure proposed by Baier and Bergstrand (2009) consisting of correcting bilateral variables to consider multilateral resistance effects. We check the robustness of our results to different estimation methods and restricting the sample to trade in different sectors. Third, our model incorporates interaction terms between our trade facilitation indicators and per capita GDP to analyze the differentiated impact of trade facilitation variables on exports by income cohorts. We find evidence that the marginal effect of infrastructure improvement on exports seems to be decreasing in per capita income. The same applies to our indicators of business environment and border-transport efficiency. In contrast, the impact of ICT on exports seems to be increasingly important for richer countries. To test on the complementarity or substitutability between hard infrastructure and soft infrastructure, we add interaction terms of both types of indicators. The statistical evidence supports that hard and soft infrastructure are complement.

Finally, drawing on the model estimates, we provide an illustrative assessment of enhanced trade facilitation for each developing country so that the value of each indicator increases halfway to the level of the top performing country in the region.

From a policy standpoint, the findings of this paper are intended to contribute to a diagnostic assessment of the constraints on export facilitation along “hard” and “soft” infrastructure, thereby contributing to the understanding of the potential gains in investment and reform along different areas to improve export performance.

The rest of the paper is organized as follows: Section 2 reviews the previous empirical literature. Section 3 describes the primary measures used as inputs in our synthetic indicators, as well as the procedure to construct them. Section 4 addresses the augmented gravity model estimates and econometric strategy. In Section 5, we provide illustrative counterfactual estimates in terms of export growth and the ad-valorem tariff equivalent of improving the indicators for developing countries halfway to the level of the top performer in their region. Section 6 briefly concludes.

2. TRADE FACILITATION: DEFINITION AND OVERVIEW OF PREVIOUS WORK

This section briefly discusses the definition of trade facilitation and surveys selected work on the impact of trade facilitation on trade. As trade facilitation has several dimensions, our survey only covers a selection of previous articles. For more extensive surveys of the literature, see for instance: Maur and Wilson (forthcoming).

There is no exact and standard definition of trade facilitation. It can be widely defined as any policy measure aimed at diminishing trade costs.[4] Trade facilitation measures can be thought of along two dimensions: investment in "hard" infrastructure (highways, railroads, ports, etc.) and in "soft" infrastructure (transparency, customs efficiency, institutional reforms, etc.). Of particular interest, this distinction makes it possible to compare the benefits and costs of investment or policy reform along both dimensions.

Empirical research assessing the impact of trade facilitation has to address three issues: defining and measuring trade facilitation indicators; choosing an econometric methodology to estimate the impact of trade facilitation on trade flows; and designing a scenario to estimate the effect of improved trade facilitation on trade flows. The methodology proposed by Wilson, Mann, and Otsuki (henceforth WMO) (2003) was the first to measure the impact of trade facilitation on trade performance using a gravity model. They focused on four dimensions of trade facilitation: port infrastructure, customs environment, regulatory environment, and e-business infrastructure. They constructed four indicators for Asia Pacific Economic Cooperation (APEC) countries for a single year by applying single averages to 13 primary variables, which were mostly collected from the WEF. They estimated a gravity model that included the four indicators as well as other typical controls, such as the income level of individual countries, geography, and tariffs. Using model estimates, WMO find that intra-APEC trade could increase by $254 billion, or 21 percent of intra-APEC trade flows, if APEC members with below-average indicators improved capacity halfway to the average for all members, about half the increase being derived from improved port efficiency.

Subsequently, Wilson, Mann, and Otsuki (2005) expanded their four indicators to a larger set of countries. Using simulations based on their gravity model, they find that the total gain in trade flows in manufacturing goods from trade facilitation of the "below-average" countries "halfway" to global average levels yields an increase in global trade of $US377 billion.

To derive our indicators, we not only collect the WEF variables used by WMO and newly defined WEF variables[5], but also incorporate recent indicators from other sources available for at least the period 2003-07. In addition, the factor analysis methodology is used not only to construct the indicators but to define the sub-groups to be considered.

Other regional studies have suggested the importance of infrastructure and institutional indicators for trade facilitation. Using a computable general equilibrium model, Abe and Wilson (2008) explore institutional trade facilitation indicators and find that reducing corruption and improving transparency in APEC countries to the average level of the region would increase trade in the region by 11percent and global welfare would expand by $406 billion. Using detailed data on transit, documentation, and ports and customs delays on Africa's exports collected by Doing Business at the World Bank, Freund and Rocha (2010) find that that transit delays have the most economically and statically significant effect on African exports. They find that a one-day reduction in inland travel times leads to a 7 percent increase in exports. Iwanow and Kirkpatrick (2008) construct aggregated indicators of trade facilitation (in the on-the-border sense), and infrastructure for 2003 and 2004, by applying simple average to primary indicators mainly collected from Doing Business and the World Development Indicators. They estimate a standard gravity model augmented with these indicators and find a positive impact of the three indicators on exports. As their paper focuses on Africa, they interact their indicators with an African dummy, and find that policies that improve their indicators yield a higher effect in African countries compared with the rest of the world.

Francois and Manchin (2007) use principal components to construct two indicators on infrastructure and two indicators on institutional quality from various primary measures, mainly collected by the World Development Indicators and the Fraser Institute. Although they find that these indicators are robust determinants of trade, they may not easily interpretable.[6]

Using indices of trade restrictiveness and trade facilitation developed at the World Bank, such as the Logistic Performance Index and Doing Business in a gravity model, Hoekman and Nicita (2008) suggest that tariffs and non-tariff measures continue to be a significant source of trade restrictiveness for low-income countries despite preferential access programs. This is because the value of trade preferences is quite limited: a new measure of the relative preference margin developed in the paper reveals that this is very low for most country-pairs.

Regarding more-specific dimensions of trade facilitation, such as the time to trade, Djankov, Freund, and Pham (2006) find that, on average, each additional day a product is delayed prior to being shipped reduces trade by at least 1 percent. Clark, Dollar, and Micco (2004) explain variations in trade costs due to port efficiency on bilateral trade flows. They show that improving port efficiency reduces shipping costs a lot. They find that improving port efficiency from the 25th to the 75th percentile can reduce shipping costs by 12 percent.

3. CONSTRUCTING TRADE FACILITATION INDICATORS

In this section we describe our procedure to obtain hard and soft infrastructure indicators. The simplest approach to obtain an aggregate indicator is to average primary variables; the underlying assumption is that the relative importance of each primary variable is proportional to its weight in the indicators. Principal component analysis is another way of reducing the multidimensionality of the data, by transforming the data to a new coordinate system such that the greatest variance by any projection of the data comes to lie in the first coordinate or principal component, the second greatest variance on the second coordinate, and so on. Factor analysis, a slightly more refined technique, proposes an explicit underlying model that attempts to "explain" correlations among a set of m observed variables ($X_1, X_2, \ldots, X_m$) through the linear combination of a few latent (unobserved) random factors (Fs). In the case of a single factor, F, the underlying model is defined as:

$$
\begin{aligned}
X_1 &= \lambda_1 F + e_1 \\
X_2 &= \lambda_2 F + e_2 \\
&\ldots\ldots\ldots\ldots\ldots\ldots \\
X_m &= \lambda_m F + e_m
\end{aligned}
$$

where λ_k is the loading factor associated with the observed variable X_k. The procedure allows estimation of the factor loadings as well as estimates of the unobserved factor F per sub-group, the latter being retained as the synthetic indicator. Loading factors provide information on the weights and correlation between each variable and the common factor; the higher the load, the more relevant is the primary variable in defining the dimensionality of a factor.[7]

Constructing the Indicators

For this exercise, we retain a pool of 18 primary variables collected from different sources, such as WEF's Global Competitiveness Report, Doing Business, the World Development Indicators,[8] and Transparency International. Two criteria were used to select the indicators that are part of the aggregated indicators: they should be available for at least the period 2004-07, and they should cover more than 100 countries.[9] Because the primary variables have different units and scales, we re-scale each indicator on a 0 to 1 continuous scale, such that a greater value indicates that the country is more advanced along the measured dimension.[10]

We perform the factor analysis procedure in two steps. First, a diagnostic factor analysis procedure contributes to define the sub-group of variables to be considered for each aggregate indicator. Second, we re-run the procedure on the sub-groups to estimate the common factor to be taken as the indicator.

In the first step, a diagnostic factor analysis procedure is performed on two separate groups of primary variables; the first group consists of variables related to hard infrastructure, and the second one puts together variables related to soft infrastructure or institutional aspects. The goal is to identify sub-groups or primary variables within hard-infrastructure indicators and within soft-infrastructure indicators that are highly correlated, so that each primary variable is exclusively mapped to an aggregate indicator. Table A1 in Appendix A shows the loading factors of the first-step procedure as well as other statistics, The loading factors estimated in the explanatory analysis show a clear regrouping of the primary variables of hard infrastructure into two sub-groups that we call physical infrastructure and information and communications technology (ICT) because of the variables considered in each of them. Similarly, two sub-groups emerge clearly among the soft infrastructure variables, and we name them: border and transport efficiency, and business and regulatory environment.

In the second step, we run four separate factor analysis procedures on each of the four sub-groups identified in the first step, with a single estimated factor retained by the data[11]. The loading factors are used to derive the aggregate indicators.

The four indicators derived from the four sub-groups of primary variables along the "soft" and "hard" dimensions of infrastructure are:

(a) Hard infrastructure*:*

1. *Physical infrastructure* measures the level of development and quality of ports, airports, roads, and rail infrastructure.

2. *Information and communications technology (ICT)* is interpreted as the extent to which an economy uses information and communications technology to improve efficiency, and productivity as well as to reduce transaction costs. It contains indicators on the availability, use, absorption, and government prioritization of ICT.

(b) Soft infrastructure*:*

3. *Border and transport efficiency* aims at quantifying the level of efficiency of customs and domestic transport that is reflected in the time, cost, and number of documents necessary for export and import procedures.

4. *Business and regulatory environment* measures the level of development of regulations and transparency. It is built on indicators of irregular payments, favoritism, government transparency, and measures to combat corruption.

(Table 1 here. Loading Factors, TF indicators)

Table 1 reports the final loading factors associated to each primary variable, as well as the percentage of variance explained by each identified factor. In all cases, the first retained factor captures a large amount of the variation, which ranges from 77 percent in the case of border and transport efficiency, to 88 percent in the case of the business environment.[12]

(Table 2 here. Summary Statistics for Values of Trade Facilitation Factors and Primary Indicators)

For simplicity, the synthetic indicators are also scaled on a range of 0 to 1. Figure 1 depicts the single indicators that are part of each aggregated indicator. Table 2 reports summary statistics on the derived indicators and the underlying primary indicators, as well as the country with the highest and lowest scores throughout the panel. [13]

(Figure 1 here. Aggregate Indicators and Single indicators)

4. TF INDICATORS AND TRADE VOLUMES: ECONOMETRIC MODEL AND RESULTS

Several studies have provided theoretical foundations for the gravity model and contributed to its popularity. These studies show that estimates can be derived from different theoretical frameworks, such as the Ricardian, Heckscher–Ohlin, and increasing returns to scale models. Theoretical foundations for estimating gravity equations were also enhanced in Anderson and van Wincoop (2003, 2004). More recently, Helpman et al. (2008) (henceforth HMR) develop an international trade model with firm heterogeneity. Their model incorporates firms with varying productivity so that only the more productive firms find it profitable to export, and the profitability of exports varies by destination, as exports are higher to countries with higher demand and lower variable and fixed export costs.[14]

We adapt the HMR framework to incorporate hard and soft infrastructure of an exporter as part of trade costs. Indeed, the better is the condition of hard and soft infrastructure in a country, the lower are the trade costs incurred with its trading. We provide a more detailed description of the derivation of the gravity model in Appendix D. As in HMR, we apply a two-stage sample selection model to take into account zero or missing bilateral trade flows. [15] The two-stage procedure aims at correcting the standard selection bias that can result from the necessity to drop observations with zero trade, as well as the bias due to the potential unobserved firm level heterogeneity.

(a) Model estimation strategy

More precisely, we estimate the following specification as the outcome equation in terms of our sample selection model:

$$\begin{aligned}\ln\left(X_{ijt}\right) &= \varphi_0 + \varphi_1 \ln(\text{Border\_Transport\_Effic}_{it}) + \varphi_2 \ln(\text{Business\_Environment}_{it}) + \varphi_3 \ln(ICT_{it}) + \\ &+ \varphi_4 \ln(Phys\_\text{Infrastruct}_{it}) + \beta_1 \ln\left(1 + t_{ijt}\right) + \beta_2 \ln(GDPpc_{it}) + \beta_3 \ln(Population_{it}) + \beta_4 \ln(GDPpc_{jt}) \\ &+ \beta_5 \ln(Population_{jt}) + \beta_6 \ln\left(Distance_{ij}\right) + \beta_7 RTA_{ijt} + \beta_8 Landlocked_i + \beta_9 \text{Border}_{ij} + \beta_{10} \text{Language}_{ij} + \\ &+ \beta_{11} \text{Colonial\_Rel}_{ij} + \beta_{12} \text{Common\_Colonizer}_{ij} + \lambda_1 Inv\_Mills_{ijt} + \lambda_2 zeta_{ijt} + \lambda_3 zeta\_sq + \tau_t + I_j + \varepsilon_{ijt}\end{aligned} \quad (1)$$

where X_{ijt} is country i exports to country j in year t; $\text{Border\_Transp\_Effic}_{it}$, $\text{Business\_Environment}_{it}$, ICT_{it}, and $\text{Phys\_Infrastruct}_{it}$ are our four infrastructure indicators for country i in year with higher values representing better performance; t_{ijt}, are tariffs on imports of country j from country i in year t; RTA_{ijt} is a dummy equal to 1 when countries i and j have an active preferential trade agreement in year t; $Landlocked_i$ is a dummy equal to1 when country i is landlocked; Border_{ij} $\text{Common\_Language}_{ij}$, $\text{Colonial\_Relation}_{ij}$, $\text{Common\_Colonizer}_{ij}$ are dummy variables that are equal to one if countries i and j, respectively, have common border, common language, same colonizers, and common colonizers post-1945. Inv_Mills is the inverse Mills ratio that corrects for selectivity in the Heckman selection model computed from the selection model below. Zeta and zeta_sq are terms included to correct for unobserved firm-heterogeneity and derived in an analogous way from HMR (2008). For a more complete derivation of the HMR model refer to Appendix D. Finally, I_j and τ_t are two vectors with importer-specific and year-specific dummies, whereas ε_{ijt} is a random error terms.

Regarding the selection estimation, we assume that X_{ijt} is observed when the following condition is met:

$$\begin{aligned}
&\alpha_0 + \alpha_1 \ln(\text{Border_Transport_Effic}_{it}) + \alpha_2 \ln(\text{Business_Environment}_{it}) + \alpha_3 \ln(ICT_{it}) + \\
&+ \alpha_4 \ln(Phys_\text{Infrastruct}_{it}) + \delta_1 \ln(1 + t_{ijt}) + \delta_2 \ln(GDPpc_{it}) + \delta_3 \ln(Population_{it}) + \delta_4 \ln(GDPpc_{jt}) \\
&+ \delta_5 \ln(Population_{jt}) + \delta_6 \ln(Distance_{ij}) + \delta_7 RTA_{ijt} + \delta_8 Landlocked_i + \delta_9 \text{Border}_{ij} + \delta_{10} \text{Language}_{ij} + \\
&+ \delta_{11} \text{Colonial_Rel}_{ij} + \beta_{12} \text{Common_Colonizer}_{ij} + \tau_t + I_j + \beta_{13} EntryCosts_{ijt} + u_{ijt} > 0
\end{aligned} \tag{2}$$

where: $EntryCosts_{ijt}$ is a binary indicator that equals 1 if the sum of the number of days and procedures to start a business is greater than the median for country i and country j, or if the sum of the relative costs of starting a business (as percentage of GDP per capita,) are greater than the median for both countries, and 0 otherwise.[16]

Equation (1) sets the determinants of the volume of trade, provided that one of the partners has positive exports to the other, while Equation (2) defines the selection criteria.

We include fixed effects for both, importers and years. A complete specification would also require fixed effects for exporters to control for multilateral resistance terms (MRTs),[17] but their inclusion can wipe out the effect of exporter-specific variables that do not vary greatly throughout the four-year panel, such as the trade facilitation indicators for exporters. As shown below, our estimates take into account multilateral resistance using by using a method analogous to Baier and Bergstrand (2007, 2009) that do not require exporter dummies.[18]

(b) Data

The dataset covers 101 countries over the period 2004-07. Aggregate trade flows were compiled from the Commodity and Trade Database (COMTRADE), whereas tariffs were compiled from TRAINS. We use the average of applied tariff rates, from 2004 to 2007[19]. Core gravity variables, such as bilateral distances, colonial ties, and common language dummies were obtained from the CEPII website. Other relevant variables, such as GDP and population, were available from the World Bank's World Development Indicators (WDI).

(c) Estimation and results

Table 3 reports estimates for the two-stage Heckman selection model defined by expressions (1) and (2). Columns 1a and 1b report the estimated coefficients of the outcome and the selection equations, respectively. Standard errors are clustered by importer-exporter pairs, following HMR. In the outcome equation, the coefficients of all four trade facilitation indicators are positive. As trade facilitation indicators are scaled on a zero-one interval, the magnitude of estimated coefficients can be informative of the relative impact of these aspects on trade. The coefficient of physical infrastructure is, indeed, the largest of all four. Business environment seems to be the next important factor for exporters, followed by border and transport efficiency and ICT.[20] All other coefficients are significant and have the expected signs. Indeed, higher tariffs, longer distance between partners discourage trade, as well as being landlocked. By contrast, the trade volume is higher between partners in a regional trade agreement, as well as between richer and more populous countries. Contiguous partners, countries having a common official language, and countries having had a common colonizer or a colonial relationship are also likely to trade more intensively. The selection equation estimates (column 1b) provide a hint on the impact of each determinant on the probability of exporting, the so-called extensive margin. Most coefficients are significant and have the same sign as in the outcome equations. Only the coefficient of business environment has a negative sign, although it is non-significant. The coefficient of the entry-cost variable appearing in the first stage is negative and significant, as countries with higher entry barriers are less likely to trade.[21]

In next estimates, we replace variables that vary across exporter-importer pairs with expressions corrected to better account for multilateral resistance following a procedure similar to Baier and Bergstrand (2009) and Behar, Manners, and Nelson (2009).[22] The estimates reported in Column 2a and 2b do not vary greatly. Whereas the coefficients of infrastructure, business environment and border and transport efficiency are larger than baseline estimates, ICT coefficient becomes negative. Yet, infrastructure and business environment remain the indicators with the greatest impact on exports.

(Table 3 here: Baseline Estimates)

We report in columns 3a and 3b estimates of a regression that includes an interaction term for each trade facilitation indicator with respect to per-capita income. All four interaction terms are significant. We plot in Figure 2 the associated marginal effects of our indicators for different levels of per-capita income. The marginal effect of the quality of infrastructure on exports seems to be decreasing in income, as its significant and negative interaction coefficient shows. The same applies to business environment as well as to border and transport efficiency. By contrast, the impact of ICT on exports seems to be increasingly important for richer countries.

(Figure 2 Marginal impacts of the indicators as function of per capita GDP)

As a variation of the baseline model, we include two interaction terms between an indicator of soft infrastructure and an indicator of hard infrastructure to test on the substitutability or complementarity character of both types of infrastructure. Columns 3a shows coefficients for the interaction terms *[Ln(Business_ Environment_i)x Ln(Phys_ Infrastruct_i)* and *Ln(Border_Transport_Effic_i)x Ln(ICT_i)]* are positive and significant pointing at the complementarity of hard and soft infrastructure. Coefficients of the indicators are positive and significant.[23]

(d) Robustness checks

A potential reverse causality problem may be present, as hard and soft infrastructure could also be driven by trade and integration, as well as the other way around. Indeed, countries exporting more may have higher returns to invest in enhancing hard or soft infrastructure. Although the causality is likely to go ways, better hard infrastructure as well as better institutional components are more likely to have a direct and immediate effect on the likelihood and the volume of exports rather than the other way around. The value of the indicators obtained in this paper does not change greatly from year to year, especially for physical infrastructure, meaning that there was not any unexpected change in trade facilitation due to an export surge or fall. Moreover, using factor analysis to construct the synthetic indicators attenuates the endogeneity problem. Nevertheless, we attempt to address the potential problem of endogeneity exploiting the lack of trade facilitation on new products.[24]

(Table 4 here: Robustness checks)

Indeed, we follow Freund and Rocha's (2010) idea and examine the effect of trade facilitation on trade in new products[25]. The intuition is that trade in goods having not been exported in the past cannot have had an impact on the historical development of either hard infrastructure or in institutions. Column 1 in table 4 reports estimates of the model when exports are restricted to new goods. Compared to baseline estimates (column 2, table 3) only the coefficients of physical infrastructure and Business Environment are positive. The effect of physical infrastructure is smaller than the baseline estimates in column 2a, table 3. On one hand, it can be interpreted as evidence that endogeneity tended to overstate the effect of physical infrastructure on exports. On the other hand, it can also be interpreted as proof that physical infrastructure has a greater impact on exports of new products (extensive margin), than in existing products (intensive margin), the latter just being a small share of total exports. It is also consistent with the previous finding that physical infrastructure has a smaller effect for richer countries, who tended to export more new products during this period.

In order to include exporter-specific dummies in addition to importer-specific dummies, we replace exporter-specific trade facilitation variables with the log of the sum of importer and exporter variables of trade facilitation, and report estimates in Column 2. The underlying assumption ─not necessary verified─ is that equal importance is given to levels of trade facilitation in the exporter and in the importer. All coefficients are significant but coefficients for ICT and Border/Transport Efficiency are negative. Indeed, as some of the indicators do not change significantly for some countries, their impact on exports may be captured by exporter-specific dummies included in this regression.

We check the consistency of the baseline estimates to OLS and the pseudo-maximum-likelihood estimator (PPML) suggested by Santos Silva and Tenreyro (2006) to deal with heteroskedasticity in constant-elasticity models. Using Monte-Carlo simulations, they show that that the PPML produces estimates with the lowest bias for different patterns of heteroskedasticity. However, Martin and Pham (2008) notice that the data-generating process used by SS-T does not produce zero-values properly. When correcting the data-generating process to obtain a sample with an important amount of zero-value observations – a situation closer to ours – Martin and Pham find that a Tobit-type of estimator and the two–stage sample selection estimates have a lower bias than those obtained with the PPML estimator. Columns 3 and 4 report these estimates. Except in the case of infrastructure, our indicators remain positive and significant.

As a final robustness check, we estimate the baseline model restricting the sample to different sectors: fuels, ores and metals, manufactures and textiles; as well as only considering exports from Southern countries to Northern countries and separately to other Southern countries. Estimates are reported in Table C3 in Appendix C. Compared to baseline estimates, the impact of physical infrastructure is greater for fuels as well as for ores and metals. Whereas ICT has a negative and significant sign for ores and metals, as well as in the last two regressions that focus on Southern exports. This can reinforce the former findings that countries with lower income tend to export those commodities and ICT tends to have a lower marginal impact the lower the income of a country.

5. POTENTIAL BENEFITS FROM TRADE FACILITATION: CONTERFACTUAL ESTIMATES

Based on our baseline estimates, we simulate the effects of improving each aspect of trade facilitation on the export performance of the developing countries in the sample.[26] As the model contains tariffs, the coefficient estimates are used to compute counterfactual ad-valorem variations that would otherwise be generated by a benchmark variation of our composite indicators. The benchmark retained in this exercise is an improvement of each exporter's indicators halfway to the level of the top performing country in the region along each indicator, along the lines of Portugal-Perez & Wilson (2009). To illustrate how these counterfactuals are estimated, suppose that regulatory reform of the Business Environment (BE) of an exporter country leads to a 1 percent increase in the BE indicator. Taking as baseline the model that includes GDP-per capita interaction, this leads to a change in trade flows of about $\left(\hat{\beta}_{BE} + \hat{\beta}_{BE\times GDPpc} \ln \overline{GDPpc}\right)$ percent for a country with and average income per capita $\left(\overline{GDPpc}\right)$ according to the gravity estimates.[27] The same change in trade flows would be brought about if all importers were to cut the tariffs applied to imports from the country by an equivalent value $\left(\hat{\beta}_{BE} + \hat{\beta}_{BE\times GDPpc} \overline{GDPpc}\right) / \hat{\beta}_{tariff}$. Therefore, the latter ratio roughly represents the "ad-valorem tariff-cut equivalent" or "ad-valorem equivalent" of a 1 percent change in the cost of export procedures inferred from gravity model estimates.

We simulate the effects of improving each aspect of trade facilitation measured by or indicators. We took into consideration the disparities among countries by performing regional simulations using the best performing country in each index as the benchmark. We estimate counterfactual estimates for many regions (reported in Appendix F), but for conciseness only estimates for Sub-Saharan Africa are shown in figure 3.

(Figure 3. Simulation Results for Africa: Ad-valorem equivalents of increasing indicators half-the-way of top performer)

In the case of Africa, for instance, if investment were to be focused on improving the physical infrastructure quality of Malawi, halfway to the level of South Africa, the ensuing expansion of exports would also be feasible with a reduction of 62 percent in tariffs in importing countries.

Appendix F reports simulations for all other regions. As expected, countries with lower values of trade facilitation indicators would experience higher export growth after the improvement along their trade facilitation indicators. In most regions, investment in physical infrastructure quality halfway to the top performer will result in the greatest trade gains.

6. CONCLUSIONS

Overall, the results show that improvement in infrastructure quality would bring the greatest benefits in terms of export growth. The analysis of the effects of these factors on trade flows provides useful information to guide policymakers on which might be the area or areas in which resource allocation would bring the greatest benefits. Among our four indicators, physical infrastructure has the greatest impact on exports in almost all specifications, and samples. Furthermore, we found evidence that the impact of physical infrastructure is decreasing with the income level, as well as ICT and border/transport efficiency. The opposite occurs with ICT, for which the richer the country, the greater its marginal impact on export performance. Our estimates also show the complementarity effects between hard and soft infrastructure as regard to export performance of developing countries.

Illustrative estimates show that improvements in infrastructure and border and transport efficiency halfway to the level of the regional top performer can be substantial. However, the high cost of investment in physical infrastructure is a factor to be considered. Of course, investment in physical infrastructure can also have large spillovers that should be taken into account in the cost-benefit analysis, but they are difficult to measure.

The net balance of costs and benefits cannot yet be stated with certainty for a given country. Such an assessment can only be made within the framework of specific infrastructure project appraisals, and it can only be addressed on a case-by-case basis. However, improvement in other areas, such as border and transport efficiency, where costs are considerably lower in comparison with investment in physical infrastructure, shows promising results for developing countries. Although general estimates on the yield of these projects is difficult to obtain, Helble, Mann, and Wilson (2009) use detailed data on aid flows to estimate the responsiveness of trade flows to specific types of foreign aid directed to enhancing trade competitiveness in developing countries. They find that relatively small amounts of aid targeted at policy and regulatory reform, in contrast to aid for broad sector-specific projects or trade-related infrastructure has relatively greater elasticity with respect to trade flows. Ferro, Portugal-Perez & Wilson (2011) find a positive impact of aid to services in developing countries on their downstream manufacture exports employing them.

In summary, this paper intends to provide policymakers information about the effectiveness of possible interventions in four areas of trade facilitation. We stress that the results presented here are targeted at stimulating discussion and helping policymakers and stakeholders arrive at a tentative prioritization of their efforts in this area. In the future, more detailed analysis is required in relation to particular reform programs, covering costs and benefits for a developing country. In addition, our results have only addressed the static impacts of trade facilitation reform, without assessing directly their impact on growth, productivity, and overall development as such. Yet, empirical evidence suggests that there are good reasons to believe that better trade facilitation can impact each of these positively.

ENDNOTES

1. See, for instance, Wilson et al. (2003, 2005), Francois and Manchin (2007), and Iwanow and Kirkpatrick (2008).
2. See, for instance, Santos-Silva and Tenreyro (2006, 2008), Helpman, Melitz, and Rubinstein (2008), Baier and Bergstran (2009), and Martin and Pham (2008).
3. The first stage consists of a probit model determining the probability that a country pair engages in trade, whereas the second stage is a gravity regression augmented by two terms. The first term corrects for selectivity that is computed from the first stage, the inverse Mills ratio, another term attempts to correct the potential bias due to unobserved firm-level heterogeneity. In order to implement the Heckman procedure on our sample, an identification variable influencing the probability of exporting but not the volume is required to comply with the exclusion restriction. We enlarge the coverage of HMR's entry cost indicator,

which reflects the fixed entry costs for a pair of trading countries, and use it to satisfy the exclusion restriction in the Heckman estimation method.

4. The meaning of trade facilitation can vary depending on the issue at hand. In a narrow sense, trade facilitation measures are usually associated with the simplification and, in some cases, the harmonization of trade regulations, both procedural and administrative, that may work as impediments to trade. For instance, the World Trade Organization (WTO) has traditionally used a narrow definition, simply saying that trade facilitation is “[t]he simplification and harmonization of international trade procedures.” Instead of focusing exclusively on factors on-the-border—such as the simplicity of export and import procedures—other “behind the border” factors, such as transparency and enhancing the business environment, have been recognized to matter for facilitating trade. Due to the rapid integration of networked information technology in almost all aspects of the international supply chain, ICT, infrastructure, and services are frequently mentioned as important facilitators of trade.
5. Some of the original WEF primary variables found by WMO (2003, 2005) are no longer constructed or were modified. We are thankful to Margareta Drzeniek Hanouz for making World Economic Forum (WEF) data available for this research.
6. We perform a robustness check by deriving four alternative indicators based upon principal components on our larger set of primary variables. As discussed later, when including these alternative indicators in our baseline specification instead of our indicators, most of the coefficients have not the expected sign. This is evidence that our procedure to derive the indicators using factor analysis deals better with a larger set of indicators that can be highly correlated.
7. For more details on factor analysis, see, for instance, Johnson & Wichern (2001) and Reyment &. Joreskog (1993).

8. Data from the World Development Indicators was included for GDP and population and for variables included in the regressions for robustness checks.
9. Some indicators providing meaningful information related to trade facilitation with less geographical or temporal coverage were not included in the exercise, such as the logistics performance index (LPI). Indeed, the LPI measures perceptions of the logistics environment in 140 countries but is only available for a single year. However, the aggregate indicators are significantly correlated with LPI for a single year, especially the physical infrastructure indicator.
10. To preserve the year variability, we use the maximum value per indicator during the whole period and re-scale the indicators accordingly.
11. In our case, the data imposes one single factor in each procedure of the second stage, according to an iterative standard procedure (see for instance Rayment and Joreskog (1996)).
12. In some cases, the factors associated to the different observed primary variables are similar --as in the group of the Business Environment indicator--. This is due to the first-step factor analysis that contributed to choose in each sub-group variables that were highly correlated.
13. Appendix B provides the some summary statistics of the aggregate indicators.
14. According to the model, the distribution of firms in country i exporting to country j is bound by a marginal firm that just breaks even when exporting to j, whereas more productive firms make positive profits when exporting to j. The model has several appealing characteristics that make it appropriate to explain some empirical patterns of trade flows. First, the model can generate asymmetric trade flows between two countries. Second, it can yield zero trade flows between some country pairs in either one or both directions. Third, the model yields a generalized gravity equation that accounts for the self-selection of firms into export markets

and their impact on trade volumes. Finally, no information on the distribution of firms in a given country is required to carry out the estimation.

15. The first stage consists of a probit regression that explains the probability that country i exports to country j (selection equation), where the dependent variable is a dummy that is equal to one if country i exports to country j. The second stage consists of a gravity equation estimated in logarithmic form that explains the volume of exports from i to j (outcome equation) and incorporates two terms based on estimates of the first stage: first, the inverse Mills ratio, to correct for the non-random prevalence of zero trade flows, the second term aims to take into consideration the unobserved firm-level heterogeneity.

16. Using Doing Business data on the regulations to start a business, we updated the indicator for fixed entry costs constructed by HMR (2008) to cover more countries and more years. By construction, this variable reflects regulation costs that should not depend on a firm's volume of exports to a given country, and satisfies the exclusion restrictions of the two-stage Heckman estimation method, as it is excluded from the outcome equation. To satisfy with the exclusion restriction, Iwanow and Kirkpatrick (2008) use an alternative variable of common religion as also suggested by Helpman et al. (2008) in their cross-section sample. However, a religion variable does not have the temporal variation necessary for our panel.

17. Anderson and van Wincoop (henceforth AvW) (2003) solve the so-called border puzzle–the implausibly large negative effect of the U.S.-Canada border on trade between Canadian provinces and U.S. states highlighted by McCallum (1995) — by showing that general equilibrium effects of changes in trade costs work through the price indices that enter the bilateral gravity equations. Indeed, traditional estimates do not control properly for theoretically motivated price index terms, which aggregate both domestic and international trade costs, and therefore capture the effect of trade with third countries on bilateral trade, or

"multilateral resistance." AvW show that bilateral trade flows depend on bilateral trade costs relative to multilateral resistance.

18. Indeed, Baier and Bergstrand (2007) recognize that one of the drawbacks of using fixed effects dummies is the preclusion of direct estimation of partial effects from numerous potentially-important explanatory variables often motivated theoretically (e.g. the effects of exporter and importer populations, foreign aid, or internal infrastructure measures on bilateral trade). As the authors argue, these variables can be subsumed in the fixed effects.
19. Estimates are not sensitive to the exclusion of the tariff variable is excluded, as is shown in table C2 in Appendix C. We report additional robustness checks in Appendix C.
20. When estimating four specifications, each containing one of the four indicators at a time, the magnitude of their coefficients do not vary greatly and their relative magnitudes remain unchanged, with physical infrastructure being the largest coefficient, as reported in table C1 of Appendix C. We report additional robustness checks in Appendix C.
21. For instance, we estimate a symmetric specification where the impact of importer-specific variables, including trade facilitation ones, on a country's imports. Estimates are similar to the baseline and are reported in table C2 of Appendix C.
22. Baier and Bergstrand (2009) introduce a method for "approximating" price index multilateral resistance terms using a first-order Taylor expansion, yielding a log-linear expression for multilateral resistance terms (MRTs) that is a function of exogenous variables. It can be included in the estimation equation to be estimated with a simple OLS method. The approach has the advantage of producing tractable comparative statistics that underline the role of country size in MRTs, as trade barriers have a large impact on the terms of small countries, which typically trade a large proportion of their output internationally. While estimating the impact of a country's trade logistics system on its exports, Behar, Manners, and Nelson

(2009) proxy MRTs using Baier and Bergstrand's method in a two-stage selection model of gravity akin to Helpman, Melitz, and Rubinstein (2008). In a nutshell, implementing the procedure consists of replacing bilateral variables that account for theoretical bilateral trade costs in the specification and vary across exporter-importer pairs for its MRT-corrected expressions. In the case of a continuous variable, such as distance, the corresponding MRT-corrected term is:

$$Distance\_MRT_{ij,t} = \ln\left(Distance_{ij}\right) - \left[\left(\sum_{k=1}^{N}\delta_{k,t}\ln(Distance_{ik})\right) + \left(\sum_{m=1}^{N}\delta_{m,t}\ln(Distance_{mj})\right) - \left(\sum_{k=1}^{N}\sum_{m=1}^{N}\delta_{k,t}\delta_{m,t}\ln(Distance_{km})\right)\right]$$

with: $\delta_{i,t} = Y_{i,t} / Y_t^T$ and the share of country i's GDP in year t ($Y_{i,t}$) as percentage of world GDP (Y_t^T). Similarly, the MRT-corrected expression for a dummy variable, such as $Border_{ij}$, is: $Border\_MRT_{ij,t} = Border_{ij} - \left[\left(\sum_{k=1}^{N}\delta_{k,t}Border_{ik}\right) + \left(\sum_{m=1}^{N}\delta_{m,t}Border_{mj}\right) - \left(\sum_{k=1}^{N}\sum_{m=1}^{N}\delta_{k,t}\delta_{m,t}Border_{km}\right)\right]$.

The MRT-corrected terms take into account the temporal variation of multilateral resistance terms as GDP shares evolve over time.

23. When using another combination of soft and hard infrastructure indicators for the interactions or when including one interaction at a time, estimates do not change significantly. Estimates are available upon request.

24. The marginal impacts are computed from estimates of the outcome equation. Yet, the outcome equation incorporates information on estimates of the selection equation through the inverse mills ratio as well as the zeta and zeta equation that are computed from estimates of the selection equation.

25. Table 4 only reports estimates for the outcome equation for briefness and includes the GDP-per-capita interaction terms as in columns 3a-3b of Table 4.

26. We define new products as goods that were not exported in the period 1999-2002 and that entered into the export market in the interval 2003-2006.

27. For simplicity, we use coefficient estimates of the outcome equation (second-stage) and disregard the marginal effects of the indicators on the selection equation (first stage) that feed in the second stage through marginal changes in the inverse Mills ratio.

28. For notation purposes, let $\hat{\beta}_X$ be the estimated elasticity of imports with respect to the variable X entering in the gravity equation. In the case of Doing Business export costs, the estimates should be negative.

29. The inverse Mills ratio, or non-selection hazard, is defined as $\hat{\eta}^*_{ij} = \phi(\hat{z}^*_{ij}) / \Phi(\hat{z}^*_{ij})$.

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Tables and Figures

Export Performance and Trade Facilitation Reform: Hard and Soft Infrastructure

Table 1. Loading Factors, Trade Facilitation Indicators

1a. Information and communications technology

Cumulative variance

Factor	Variance	Proportion
ICT	3.41	0.85

Factor loadings

Variable	Factor1	Uniqueness
Availability of latest ICT technology	0.96	0.08
Level of technology absorption	0.93	0.13
Extent of business internet use	0.93	0.14
Government prioritization of ICT	0.87	0.24

Source: Authors' calculations.

1b. Physical infrastructure

Cumulative variance

Factor	Variance	Proportion
Infrastructure	3.30	0.83

Factor loadings

Variable	Factor1	Uniqueness
Quality of ports infrastructure	0.94	0.11
Quality of airports infrastructure	0.92	0.16
Quality of roads infrastructure	0.94	0.11
Quality of railroad infrastructure	0.82	0.32

Source: Authors' calculations.

1c. Business environment

Cumulative variance

Factor	Variance	Proportion
Business environment	5.30	0.88

Factor loadings

Variable	Factor1	Uniqueness
Government transparency	0.96	0.09
Public trust for government	0.92	0.16
Irreg. payments in exports and imports	0.92	0.15
Irreg. payments in public contracts	0.96	0.08
Measures to combat corruption	0.95	0.09
Favoritism of gov. to well-connected firms	0.93	0.14

Source: Authors' calculations.

1d. Border and transport efficiency

Cumulative variance

Factor	Variance	Proportion
Eff. trading across borders	3.09	0.77

Factor loadings

Variable	Factor1	Uniqueness
Number of documents to export	0.83	0.32
Number of days to export	0.92	0.15
Number of documents to import	0.86	0.26
Number of days to import	0.91	0.17

Source: Authors' calculations.

Table 2. Summary Statistics for Values of Trade Facilitation Factors and Primary Indicators

Indices/variables	**Mean**	**SD**	**Lowest performance**		**Highest performance**		**Source**
Information and Communications Tech. Indicator	**0.49**	**0.24**	**Zimbabwe**	**0.01**	**Sweden**	**1**	
Availability of latest ICT technology	0.62	0.19	Moldova	0.27	Sweden	1	WEF
Level of technology absorption	0.73	0.13	Bolivia	0.41	Iceland	1	WEF
Extent of business internet use	0.62	0.17	Algeria	0.32	Rep. of Korea	1	WEF
Government prioritization of ICT	0.68	0.14	Zimbabwe	0.33	Singapore	1	WEF
Physical Infrastructure Indicator	**0.49**	**0.24**	**Bosnia & Herzegovina**	**0.05**	**Singapore**	**1**	
Quality of ports infrastructure	0.56	0.21	Armenia	0.17	Singapore	1	WEF
Quality of airports infrastructure	0.67	0.16	Paraguay	0.27	Singapore	1	WEF
Quality of roads infrastructure	0.57	0.21	Mongolia	0.23	France	1	WEF
Quality of railroad infrastructure	0.46	0.23	Paraguay	0.15	Switzerland	1	WEF
Border and Transport Efficiency Indicator	**0.69**	**0.19**	**Kazakhstan**	**0.02**	**France**	**1**	
Number of documents to export	0.50	0.16	Kyrgyzstan	0.15	France	1	DB
Number of days to export	0.25	0.16	Kazakhstan	0.06	Estonia	1	DB
Number of documents to import	0.49	0.17	Azerbaijan	0.14	France	1	DB
Number of days to import	0.25	0.16	Kazakhstan	0.03	Singapore	1	DB
Business Environment Indicator	**0.44**	**0.25**	**Bangladesh**	**0.01**	**Denmark**	**1**	
Government transparency	0.48	0.24	Bangladesh	0.15	Finland	1	TI
Public trust for government	0.44	0.19	Zimbabwe	0.18	Singapore	1	WEF`
Irreg. payments in exports and imports	0.70	0.17	Bangladesh	0.34	Denmark	1	WEF
Irreg. payments in public contracts	0.63	0.17	Bangladesh	0.26	Iceland	1	WEF
Measures to combat corruption	0.67	0.16	Cameroon	0.35	Finland	1	WEF
Favoritism of gov. to well-connected firms	0.59	0.17	Venezuela	0.28	Finland	1	WEF

Note: Each variable and factor was standardized to values that range from 0 to 1 to facilitate comparison.

Source: Authors' calculations based on raw data from World Economic Forum (WEF), Doing Business (DB), and Transparency International (TI).

Table 3. Baseline Estimates

	No GDP-Interaction, no-MRT		No GDP-Interaction		GDP-Interaction		TF-interaction	
	1(a) outcome	1(b) selection	2(a) outcome	2(b) selection	3(a) outcome	3(b) selection	4(a) outcome	4(b) selection
Ln(Border_Transport_Effic_i)	0.070	0.262	0.116	0.271	0.975	-0.554	0.219	0.423
	[0.041]*	[0.032]***	[0.065]*	[0.033]***	[0.399]**	[0.217]**	[0.100]**	[0.049]***
Ln(Business_Environment_i)	0.148	-0.051	0.173	-0.014	0.536	-0.342	0.333	-0.016
	[0.047]***	[0.034]	[0.050]***	[0.035]	[0.224]**	[0.179]*	[0.079]***	[0.069]
Ln(ICT_i)	0.015	0.062	-0.255	0.028	-1.951	-0.344	0.150	0.198
	[0.051]	[0.032]*	[0.054]***	[0.032]	[0.244]***	[0.193]*	[0.068]**	[0.044]***
Ln(Physical Infrastructure_i)	0.497	0.209	0.613	0.219	1.077	0.996	0.634	0.155
	[0.071]***	[0.050]***	[0.075]***	[0.049]***	[0.378]***	[0.297]***	[0.098]***	[0.086]*
Ln(GDPpc_i)*Ln(Border_Transport_Effic_i)					-0.113	0.102		
					[0.050]**	[0.027]***		
Ln(GDPpc_i)*Ln(Business_Environment_i)					-0.061	0.039		
					[0.031]**	[0.025]		
Ln(GDPpc_i)*Ln(ICT_i)					0.274	0.064		
					[0.033]***	[0.028]**		
Ln(GDPpc_i)*Ln(Phys. Infrastructure_i)					-0.085	-0.113		
					[0.046]*	[0.039]***		
Ln(Business_Environment_i)*Ln(Phys. Infrastructure_i)							0.182	0.015
							[0.063]***	[0.055]
Ln(Border_Transport_Effic_i)*Ln(ICT_i)							0.154	0.139
							[0.068]**	[0.033]***
Ln(GDPpc_i)	0.862	0.303	1.025	0.315	0.903	0.339	0.832	0.296
	[0.023]***	[0.017]***	[0.025]***	[0.017]***	[0.031]***	[0.027]***	[0.024]***	[0.018]***
Ln(Population_i)	1.030	0.393	1.106	0.408	1.022	0.391	1.027	0.392
	[0.016]***	[0.014]***	[0.022]***	[0.015]***	[0.016]***	[0.014]***	[0.016]***	[0.014]***
Ln(GDPpc_j)	0.164	0.798	0.073	0.768	0.136	0.809	0.158	0.806
	[0.095]*	[0.103]***	[0.099]	[0.100]***	[0.095]	[0.103]***	[0.095]*	[0.103]***
Ln(Population_j)	4.803	-3.586	4.117	-3.414	4.655	-3.692	4.748	-3.644
	[0.655]***	[0.840]***	[0.684]***	[0.826]***	[0.653]***	[0.845]***	[0.655]***	[0.842]***
Ln(1+Tariff_ij)	-1.306	-0.206	-1.832	-0.239	-1.278	-0.220	-1.309	-0.218
	[0.346]***	[0.209]	[0.370]***	[0.216]	[0.344]***	[0.208]	[0.346]***	[0.208]
Ln(Distance_ij)	-0.898	-0.334	-0.024	-0.019	-0.917	-0.335	-0.908	-0.336
	[0.032]***	[0.032]***	[0.002]***	[0.003]***	[0.032]***	[0.032]***	[0.032]***	[0.032]***
RTA_ij	0.334	0.802	0.802	0.690	0.329	0.790	0.336	0.785
	[0.068]***	[0.149]***	[0.049]***	[0.074]***	[0.068]***	[0.149]***	[0.068]***	[0.147]***
Landlocked_i	-0.097	-0.200	0.062	-0.168	-0.161	-0.249	-0.149	-0.226
	[0.056]*	[0.041]***	[0.060]	[0.041]***	[0.061]***	[0.045]***	[0.058]***	[0.042]***
Entry_cost_ij		-0.108		-0.206		-0.080		-0.073
		[0.061]*		[0.061]***		[0.060]		[0.061]
Common_Border_ij	1.225	-0.113	2.167	0.526	1.201	-0.087	1.226	-0.081
	[0.121]***	[0.239]	[0.117]***	[0.217]**	[0.121]***	[0.238]	[0.122]***	[0.238]
Common_Language_ij	0.342	0.561	0.562	0.601	0.311	0.566	0.322	0.567
	[0.067]***	[0.061]***	[0.061]***	[0.060]***	[0.067]***	[0.061]***	[0.067]***	[0.061]***
Colonial_Relationship_ij	0.537	-0.730	-0.028	-0.597	0.567	-0.724	0.545	-0.753
	[0.099]***	[0.148]***	[0.085]	[0.134]***	[0.099]***	[0.146]***	[0.099]***	[0.148]***
Common_Colonizer_ij	0.969	0.089	1.270	0.163	0.989	0.076	0.952	0.090
	[0.096]***	[0.067]	[0.106]***	[0.068]**	[0.096]***	[0.068]	[0.096]***	[0.067]
mills	3.315		4.863		3.141		3.224	
	[0.386]***		[0.456]***		[0.380]***		[0.380]***	
zeta	2.803		3.487		2.732		2.778	
	[0.184]***		[0.226]***		[0.182]***		[0.182]***	
zeta_sq	-0.359		-0.476		-0.349		-0.356	
	[0.026]***		[0.034]***		[0.026]***		[0.026]***	
Constant	-67.801	49.639	-69.647	43.949	-65.548	51.032	-66.388	50.699
	[8.304]***	[13.863]***	[8.642]***	[13.619]***	[8.278]***	[13.936]***	[8.301]***	[13.893]***
Observations	35762	40400	35762	40400	35762	40400	35762	40400
R-squared	0.76		0.73		0.76		0.76	

All regressions include time and importer fixed effects. Robust standard errors in brackets (clustered by country pairs).
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4. Robustness Checks

	New Goods	Sum[1]	PPML	OLS
	1	2	3	4
	outcome	outcome	outcome	outcome
Ln(Border_Transport_Effic_i)	0.089	-0.492	0.052	0.041
	[0.056]	[0.141]***	[0.010]***	[0.007]***
Ln(Business_Environment_i)	0.16	0.274	-0.017	-0.013
	[0.044]***	[0.125]**	[0.006]***	[0.005]**
Ln(ICT_i)	-0.094	-1.406	0.036	0.025
	[0.086]	[0.135]***	[0.009]***	[0.006]***
Ln(Physical Infrastructure_i)	0.095	1.233	0.026	0.023
	[0.056]*	[0.238]***	[0.010]**	[0.008]***
Ln(GDPpc_i)	0.665	-0.164	0.037	0.033
	[0.023]***	[0.112]	[0.003]***	[0.003]***
Ln(Population_i)	0.643	-3.044	0.047	0.042
	[0.020]***	[0.748]***	[0.002]***	[0.002]***
Ln(GDPpc_j)	1.248	-0.124	0.138	0.115
	[0.068]***	[0.108]	[0.017]***	[0.014]***
Ln(Population_j)	7.529	4.583	-1.042	-0.821
	[0.667]***	[0.707]***	[0.147]***	[0.119]***
Ln(1+Tariff_ij)	-1.069	-2.088	-0.029	-0.025
	[0.307]***	[0.374]***	[0.044]	[0.036]
Ln(Distance_ij)	0.007	-0.05	0	0
	[0.001]***	[0.004]***	[0.000]	[0.000]
RTA_ij	0.512	1.124	0.01	0.012
	[0.041]***	[0.053]***	[0.004]***	[0.003]***
Landlocked_i	-0.082	5.656	-0.039	-0.031
	[0.053]	[2.139]***	[0.009]***	[0.007]***
Common_Border_ij	0.794	2.157	0.05	0.047
	[0.108]***	[0.117]***	[0.010]***	[0.010]***
Common_Language_ij	-0.177	0.858	0.024	0.026
	[0.043]***	[0.070]***	[0.005]***	[0.004]***
Colonial_Relationship_ij	0.234	0.526	0	-0.005
	[0.073]***	[0.105]***	[0.008]	[0.007]
Common_Colonizer_ij	0.844	0.999	0.074	0.06
	[0.086]***	[0.101]***	[0.014]***	[0.012]***
mills	2.981	2.702		
	[0.314]***	[0.339]***		
zeta	2.757	2.309		
	[0.152]***	[0.161]***		
zeta_sq	-0.316	-0.246		
	[0.021]***	[0.022]***		
Observations	26380	35762	40400	40400
R-squared	0.60	0.81		0.28

All regressions include time and importer fixed effects. Robust standard errors in brackets (clustered by country pairs).

* significant at 10%; ** significant at 5%; *** significant at 1%

Regressions include multilateral resistance terms corrections for distance, RTAs, common border, common language, colonial relationship, and common colonizer post-1945.

1. Specification includes time, exporter, and importer fixed effects.

Figure 1. Aggregate Indicators and Single indicators

HARD INFRASTRUCTURE INDICATORS

ICT

- Availability of latest ICT technology
- Level of technology absorption
- Extent of business internet use
- Government prioritization of ICT

PHYSICAL INFRASTRUCTURE

- Quality of ports infrastructure
- Quality of airports infrastructure
- Quality of roads infrastructure
- Quality of railroad infrastructure

SOFT INFRASTRUCTURE INDICATORS

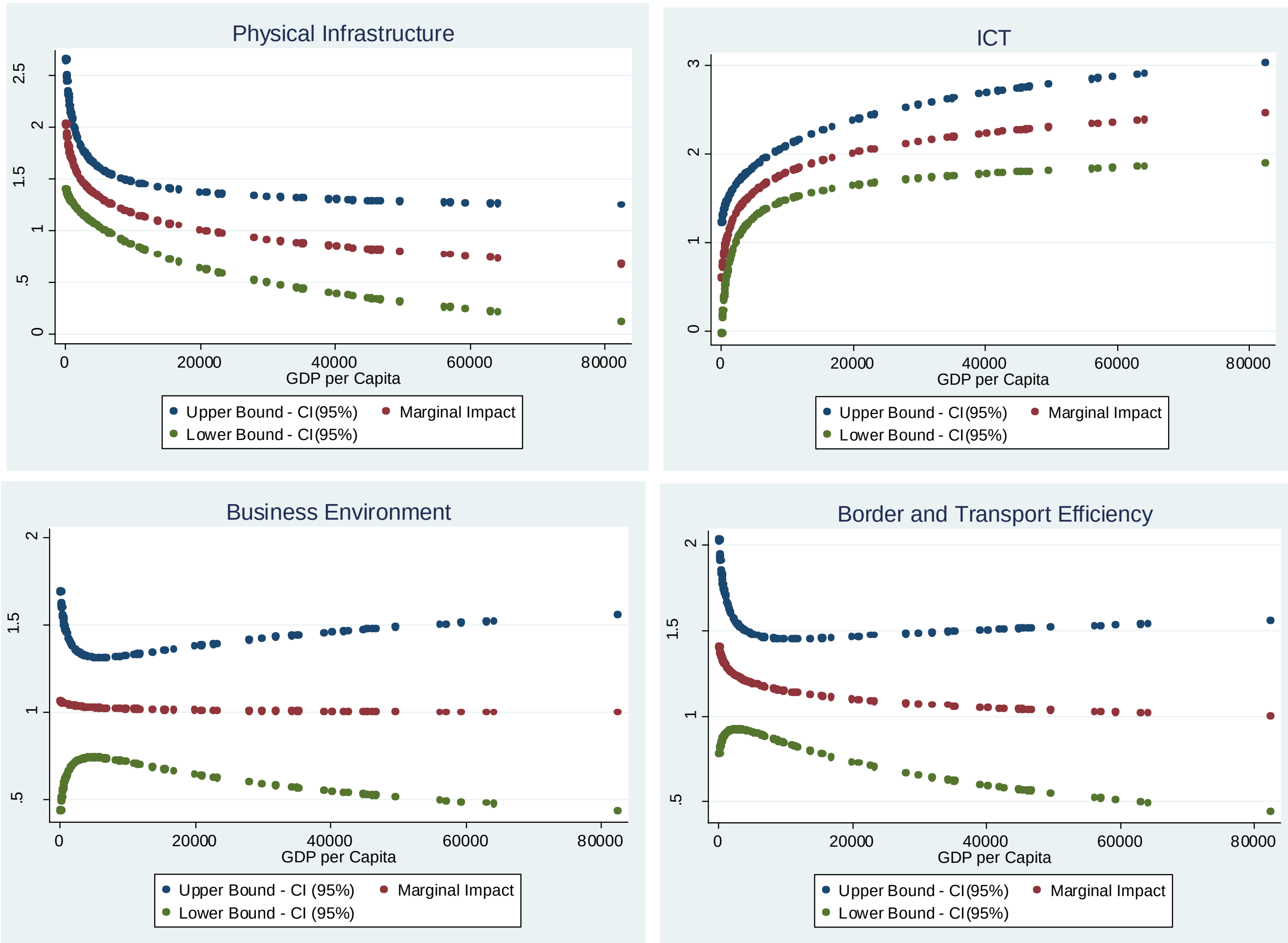
BUSINESS ENVIRONMENT

- Government transparency
- Public trust for government
- Irreg. payments in exports and imports
- Irreg. payments in public contracts
- Measures to combat corruption
- Favoritism of gov. to well-connected firms

BORDER AND TRANSPORT EFFICIENCY

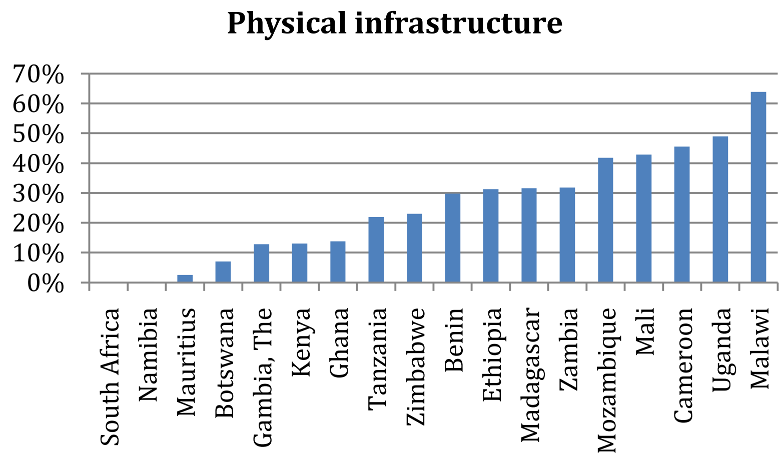
- Number of documents to export
- Number of days to export
- Number of documents to import
- Number of days to import

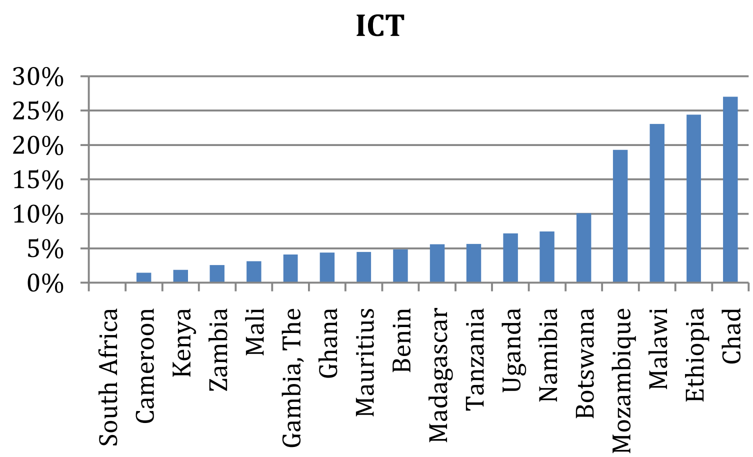
Figure 2. Marginal Impact of the Indicators as a Function of Per Capita GDP



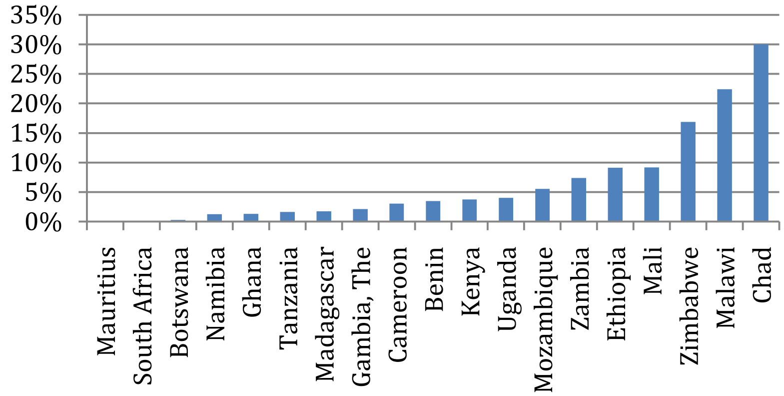
Source: Author estimates. Confidence intervals (CI) at the 95%

Figure 3. Simulation Results for Africa: Ad-valorem equivalents of increasing indicators half-the-way of top performer

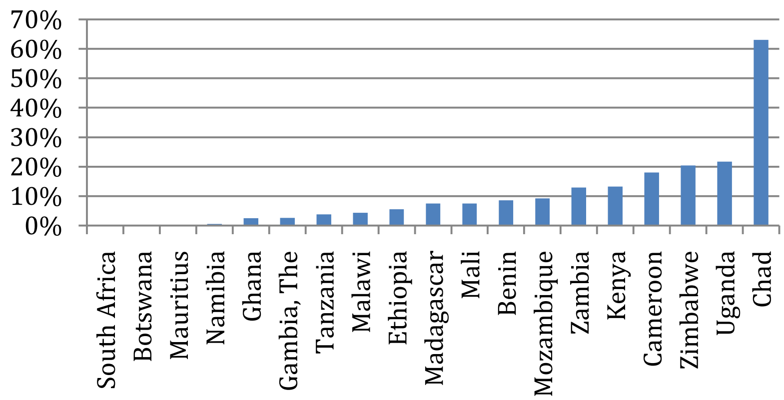




Border & transport efficiency



Business environment



Note: Chad has a corresponding value of 112% in physical infrastructure and Zimbabwe has a corresponding value of 59% in Business Environment. They are not represented in the graphs due to scale differences.

Source: Authors' calculations.

<u>Not Submitted for Publication</u>

Appendices to

Export Performance and Trade Facilitation Reform:

Hard and Soft Infrastructure

Appendix A. Loading Factors in Exploratory Factor Analysis

a. Hard infrastructure

Factors	Variance	Difference	Proportion	Cumulative
Factor1	***3.27***	***0.21***	***0.52***	***0.52***
Factor2	***3.05***	***.***	***0.48***	***1.00***

	Factor Loadings		
Variable	**Factor 1**	**Factor 2**	**Uniqueness**
Availability of latest ICT technology	**0.78**	0.58	0.07
Extent of business internet use	**0.76**	0.49	0.18
Level of technology absorption	**0.75**	0.51	0.18
Government prioritization of ICT	**0.70**	0.40	0.35
Quality of roads infrastructure	0.48	**0.79**	0.15
Quality of ports infrastructure	0.51	**0.77**	0.15
Quality of airports infrastructure	0.58	**0.69**	0.18
Quality of railroad infrastructure	0.44	**0.62**	0.43

b. Soft infrastructure or institutional variables

Factors	Variance	Difference	Proportion	Cumulative
Factor1	***5.03***	***1.93317***	***0.60***	***0.60***
Factor2	***3.09***	***.***	***0.37***	***0.97***

Variable	Factor Loadings: Factor 1	Factor 2	Uniqueness
Public trust for government	**0.90**	0.20	0.16
Favoritism of gov. to well-connected firms	**0.90**	0.23	0.15
Irreg. payments in public contracts	**0.89**	0.34	0.09
Measures to combat corruption	**0.86**	0.39	0.12
Government transparency	**0.86**	0.42	0.09
Irreg. payments in exports and imports	**0.81**	0.43	0.16
Number of days to export	0.31	**0.88**	0.13
Number of days to import	0.36	**0.85**	0.14
Number of documents to import	0.38	**0.68**	0.39
Number of documents to export	0.37	**0.64**	0.46

Appendix B. Trade Facilitation Aggregated Indicators and summary statistics

In this Appendix, we provide some statistics of the derived indicators across regions and years. Figure B1 shows the average value of each indicator by region, benchmarked against the average value of OECD countries, at the right of each panel. Sub-Saharan African (SSA) countries have on average the lowest values, except along the Business Environment indicator, where South Asian (SAS) countries have a poorer average performance. Figure B2 illustrates the relative temporal variation of indicators per region. East Asia and the Pacific (EAP) seem to have an improvement along the Border and Transport Efficiency indicator and Business Environment indicator by the end of the period that is relatively larger than other regions. There is a generalized upward evolution of the ICT indicator across regions. Unsurprisingly, infrastructure is the indicator that evolves less over time (notice the different scale in the vertical axis for all graphs).

Figure B1. Average Value of Trade Facilitation Indicators by Region

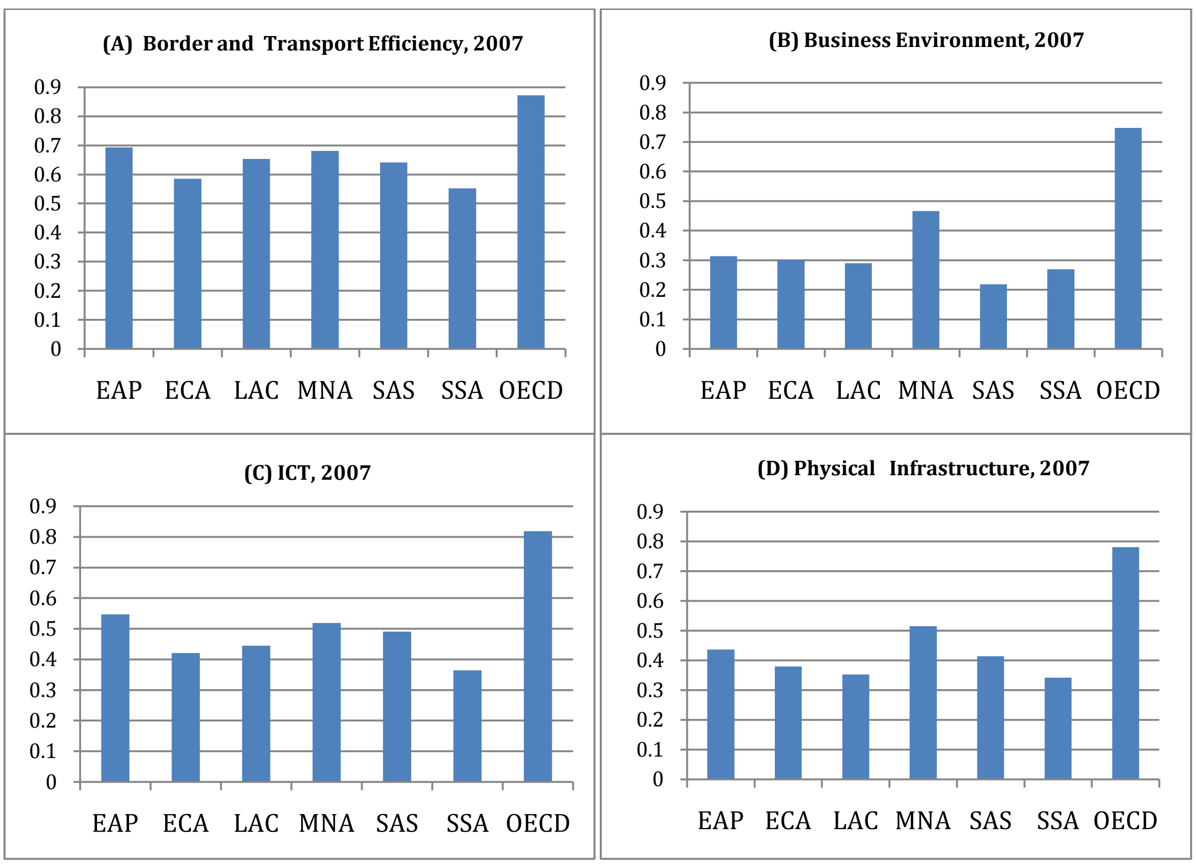


Figure B2. Temporal Evolution of Indicators (Base=1 in 2004)

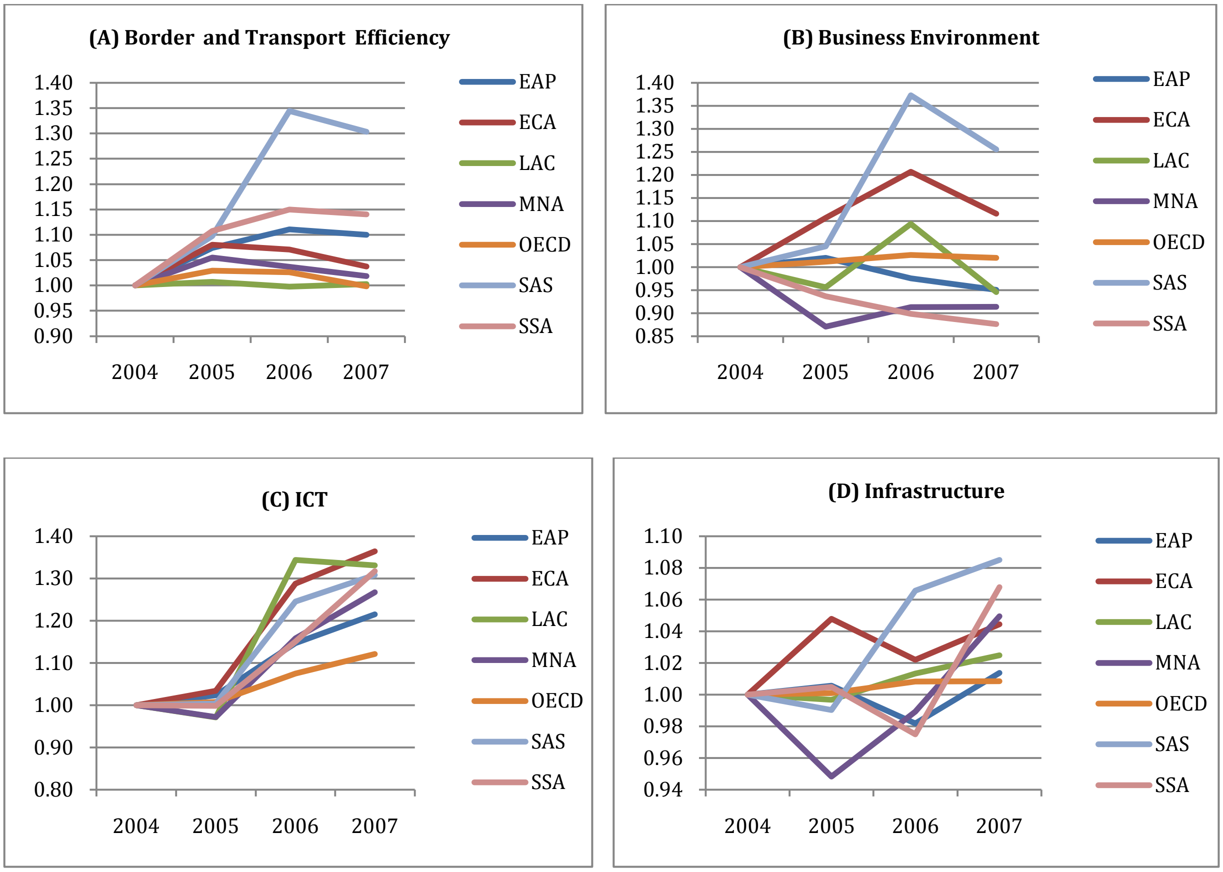


Table B1. Trade Facilitation Variables, 2006

Hard Infrastructure				Soft Infrastructure			
	ICT		Physical infrastructure		Business Environment		Border and Transport Efficiency
Iceland	1.00	Singapore	1.00	Denmark	1.00	Estonia	1.00
Sweden	0.96	Germany	1.00	New Zealand	0.99	Denmark	1.00
Finland	0.92	Hong Kong SAR	0.98	Singapore	0.99	Sweden	0.98
Denmark	0.92	France	0.96	Finland	0.98	Singapore	0.98
Israel	0.91	Netherlands	0.94	Iceland	0.98	Canada	0.97
Singapore	0.91	Japan	0.94	Norway	0.92	Panama	0.97
Estonia	0.91	Denmark	0.93	Switzerland	0.90	Hong Kong SAR	0.97
United States	0.89	Switzerland	0.92	Sweden	0.90	Norway	0.96
Switzerland	0.89	Belgium	0.89	Netherlands	0.89	United States	0.95
Korea, Rep.	0.89	Finland	0.87	Luxembourg	0.87	Netherlands	0.94
Norway	0.88	United States	0.86	Germany	0.86	Ireland	0.94
Japan	0.87	United Kingdom	0.83	Australia	0.84	Luxembourg	0.94
Germany	0.87	Malaysia	0.83	Hong Kong SAR	0.83	Germany	0.94
United Kingdom	0.84	Canada	0.82	United Kingdom	0.82	Austria	0.93
Canada	0.83	Sweden	0.82	Austria	0.80	Finland	0.93
Netherlands	0.83	Spain	0.77	Japan	0.74	Belgium	0.93
Malaysia	0.82	Austria	0.77	Chile	0.72	Switzerland	0.93
Hong Kong SAR	0.82	Korea, Rep.	0.75	United Arab Emirates	0.72	United Kingdom	0.92
Austria	0.79	United Arab Emirates	0.75	Canada	0.72	Japan	0.91
Australia	0.78	Australia	0.75	Qatar	0.71	France	0.90
Chile	0.77	Norway	0.73	France	0.70	Israel	0.90
United Arab Emirates	0.77	Luxembourg	0.72	Portugal	0.68	Korea, Rep.	0.89
India	0.77	Portugal	0.71	Ireland	0.68	Iceland	0.86
France	0.75	Israel	0.69	Belgium	0.67	Romania	0.85
Ireland	0.74	New Zealand	0.68	Israel	0.66	United Arab Emirates	0.84
Thailand	0.72	Iceland	0.66	Uruguay	0.63	New Zealand	0.84
New Zealand	0.68	Thailand	0.66	Slovenia	0.63	Australia	0.84

Belgium	0.67	Tunisia	0.65	Tunisia	0.62	Bahrain	0.83
Brazil	0.66	South Africa	0.65	United States	0.61	Lithuania	0.83
Qatar	0.65	Chile	0.65	Malaysia	0.61	Italy	0.82
Tunisia	0.65	Namibia	0.63	Estonia	0.60	Latvia	0.82
Luxembourg	0.64	Estonia	0.60	Spain	0.58	Serbia and Montenegro	0.82
Czech Republic	0.62	Greece	0.60	Jordan	0.54	Mauritius	0.82
Portugal	0.62	Panama	0.60	Bahrain	0.53	Mexico	0.82
Spain	0.60	Bahrain	0.60	South Africa	0.52	Poland	0.81
Italy	0.58	Lithuania	0.58	Botswana	0.51	Dominican Republic	0.80
Turkey	0.58	Latvia	0.57	El Salvador	0.50	Spain	0.80
South Africa	0.58	Slovenia	0.56	Kuwait	0.46	Trinidad and Tobago	0.80
Slovak Republic	0.58	Qatar	0.55	Costa Rica	0.46	Egypt	0.79
Jamaica	0.57	Ireland	0.54	Italy	0.45	Czech Republic	0.79
Hungary	0.57	Kuwait	0.54	Korea, Rep.	0.45	Hungary	0.79
El Salvador	0.57	Mauritius	0.54	Greece	0.44	Greece	0.78
Guatemala	0.57	Jamaica	0.53	Hungary	0.44	Tunisia	0.78
Panama	0.56	India	0.53	Latvia	0.44	Portugal	0.77
Dominican Republic	0.56	Czech Republic	0.53	India	0.43	Qatar	0.77
Slovenia	0.55	Jordan	0.53	Slovak Republic	0.43	Indonesia	0.77
Lithuania	0.55	El Salvador	0.53	Czech Republic	0.42	Jamaica	0.76
Mexico	0.54	Azerbaijan	0.50	Egypt	0.42	Bosnia and Herzegovina	0.76
Philippines	0.53	Pakistan	0.49	Lithuania	0.41	Bulgaria	0.75
Latvia	0.53	Croatia	0.48	Thailand	0.40	Malaysia	0.75
China	0.51	Morocco	0.46	Peru	0.39	Georgia	0.75
Bahrain	0.51	Slovak Republic	0.46	Algeria	0.39	Chile	0.74
Peru	0.51	China	0.46	Turkey	0.39	Turkey	0.74
Jordan	0.50	Italy	0.46	Mauritius	0.39	China	0.72
Azerbaijan	0.49	Egypt	0.46	Poland	0.38	Tanzania	0.72
Kuwait	0.49	Dominican Republic	0.45	Colombia	0.38	Ghana	0.72
Uruguay	0.49	Hungary	0.45	Guatemala	0.38	Slovenia	0.72
Egypt	0.47	Mexico	0.44	Croatia	0.37	Jordan	0.72
Costa Rica	0.47	Turkey	0.42	Ghana	0.37	Sri Lanka	0.71
Morocco	0.46	Poland	0.41	Mexico	0.37	Colombia	0.71
Colombia	0.46	Russian Federation	0.40	Bulgaria	0.37	Thailand	0.70

Argentina	0.45	Ghana	0.39	Namibia	0.35	Croatia	0.70
Kazakhstan	0.45	Guatemala	0.38	Gambia	0.35	Gambia	0.70
Pakistan	0.44	Botswana	0.38	China	0.34	Vietnam	0.70
Kenya	0.43	Uruguay	0.38	Jamaica	0.34	Brazil	0.69
Poland	0.43	Sri Lanka	0.37	Tanzania	0.34	Nicaragua	0.69
Venezuela	0.43	Tanzania	0.37	Moldova	0.34	Philippines	0.69
Croatia	0.42	Argentina	0.36	Panama	0.32	Costa Rica	0.69
Romania	0.42	Honduras	0.36	Morocco	0.32	Slovak Republic	0.68
Russian Federation	0.42	Kenya	0.35	Brazil	0.32	Argentina	0.68
Indonesia	0.42	Gambia	0.34	Kazakhstan	0.31	Albania	0.66
Greece	0.42	Trinidad and Tobago	0.34	Ethiopia	0.31	India	0.65
Tanzania	0.41	Kazakhstan	0.34	Serbia and Montenegro	0.30	Bangladesh	0.65
Cambodia	0.40	Georgia	0.33	Malawi	0.30	Algeria	0.65
Nigeria	0.40	Bulgaria	0.33	Ukraine	0.29	Moldova	0.65
Trinidad and Tobago	0.40	Colombia	0.33	Pakistan	0.29	Peru	0.64
Vietnam	0.39	Ukraine	0.32	Nicaragua	0.28	Pakistan	0.63
Mauritius	0.39	Brazil	0.31	Armenia	0.28	Morocco	0.63
Sri Lanka	0.38	Cambodia	0.31	Indonesia	0.28	Bolivia	0.62
Madagascar	0.38	Romania	0.30	Georgia	0.27	Kuwait	0.62
Mali	0.37	Algeria	0.30	Bosnia and Herzegovina	0.25	Armenia	0.62
Ghana	0.37	Philippines	0.29	Azerbaijan	0.25	Honduras	0.62
Uganda	0.36	Vietnam	0.28	Dominican Republic	0.24	Uganda	0.61
Namibia	0.36	Zimbabwe	0.28	Mozambique	0.24	Guyana	0.61
Armenia	0.35	Ecuador	0.28	Honduras	0.23	El Salvador	0.60
Gambia	0.35	Indonesia	0.28	Trinidad and Tobago	0.23	Madagascar	0.60
Ecuador	0.34	Venezuela	0.26	Mali	0.23	Benin	0.59
Botswana	0.33	Nigeria	0.25	Russian Federation	0.22	Mongolia	0.58
Ukraine	0.31	Zambia	0.25	Madagascar	0.22	Cameroon	0.57
Honduras	0.30	Costa Rica	0.25	Mongolia	0.22	Botswana	0.57
Benin	0.30	Armenia	0.24	Sri Lanka	0.21	Ukraine	0.57
Algeria	0.29	Bangladesh	0.23	Vietnam	0.21	South Africa	0.56
Nicaragua	0.29	Nicaragua	0.23	Albania	0.21	Kenya	0.55
Bangladesh	0.28	Peru	0.22	Romania	0.21	Uruguay	0.55
Georgia	0.27	Ethiopia	0.22	Philippines	0.21	Mozambique	0.54
Serbia and Montenegro	0.26	Guyana	0.22	Bolivia	0.20	Guatemala	0.54

Bolivia	0.25	Moldova	0.22	Argentina	0.20	Ecuador	0.53
Bulgaria	0.24	Mozambique	0.21	Guyana	0.20	Namibia	0.52
Mongolia	0.23	Madagascar	0.20	Kenya	0.18	Paraguay	0.50
Bosnia and Herzegovina	0.23	Uganda	0.20	Nigeria	0.17	Ethiopia	0.49
Zambia	0.22	Serbia and Montenegro	0.18	Ecuador	0.17	Nigeria	0.49
Cameroon	0.20	Malawi	0.17	Zimbabwe	0.17	Russian Federation	0.44
Ethiopia	0.20	Benin	0.17	Paraguay	0.17	Zambia	0.42
Moldova	0.19	Mongolia	0.16	Benin	0.16	Venezuela	0.40
Malawi	0.19	Paraguay	0.16	Uganda	0.15	Zimbabwe	0.39
Guyana	0.17	Albania	0.15	Cameroon	0.13	Cambodia	0.37
Paraguay	0.16	Kyrgyz Republic	0.15	Kyrgyz Republic	0.13	Mali	0.33
Zimbabwe	0.15	Mali	0.13	Cambodia	0.13	Malawi	0.31
Mozambique	0.14	Bolivia	0.12	Venezuela	0.12	Azerbaijan	0.28
Kyrgyz Republic	0.14	Cameroon	0.11	Chad	0.09	Chad	0.20
Albania	0.11	Bosnia and Herzegovina	0.10	Zambia	0.07	Kyrgyz Republic	0.07
Chad	0.06	Chad	0.04	Bangladesh	0.02	Kazakhstan	0.02

Note: Each variable was standardized to a 0 to 1 range over the period 2003-06 to facilitate comparison.

Source: Authors' calculations.

Appendix C.

Additional Robustness Checks

In this Appendix, we report additional robustness checks.

Table C1

	1	2	3	4	5
Ln(Infrastructure_i)	0.496	0.558			
	[0.044]***	[0.034]***			
Ln(ICT_i)	0.013		0.028		
	[0.036]		[0.026]***		
Ln(Border_Transport_Effic_i)	0.073			0.054	
	[0.040]*			[0.032]*	
Ln(Business_ Environment_i)	0.15				0.34
	[0.030]***				[0.025]***
Ln(GDP_i)	0.863	1.035	1.106	1.175	1.077
	[0.014]***	[0.012]***	[0.011]***	[0.009]***	[0.011]***
Ln(Population_i)	0.169	0.097	0.032	-0.017	0.087
	[0.014]***	[0.012]***	[0.011]***	[0.010]*	[0.012]***
Ln(1+Tariff_ij)	-1.302	-1.446	-1.389	-1.418	-1.356
	[0.221]***	[0.187]***	[0.187]***	[0.188]***	[0.187]***
Landlocked_i	-0.097	-0.08	-0.12	-0.137	-0.141
	[0.033]***	[0.031]***	[0.031]***	[0.033]***	[0.031]***
Ln(Distance_ij)	-0.9	-1.047	-1.056	-1.041	-1.045
	[0.018]***	[0.019]***	[0.019]***	[0.019]***	[0.019]***
RTA_ij	0.333	0.506	0.518	0.543	0.507
	[0.038]***	[0.041]***	[0.041]***	[0.041]***	[0.041]***
Border	1.225	1.091	1.063	1.059	1.083
	[0.064]***	[0.075]***	[0.075]***	[0.075]***	[0.075]***
Common_Language	0.345	0.426	0.421	0.416	0.397
	[0.037]***	[0.039]***	[0.039]***	[0.039]***	[0.039]***
Colonial_Relationship	0.536	0.532	0.558	0.549	0.547
	[0.052]***	[0.084]***	[0.084]***	[0.085]***	[0.085]***
Common_Colonizer	0.969	0.915	0.978	1.027	1.01
	[0.056]***	[0.051]***	[0.051]***	[0.051]***	[0.051]***
Constant	-3.554	-0.999	-3.907	-3.02	-4.012
	[0.487]***	[0.314]***	[0.315]***	[0.294]***	[0.302]***
Observations	40400	40400	40400	40400	40400

All regressions include time and importer fixed effects. Robust standard errors are in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Source: Authors' calculations based on data from COMTRADE for trade flows; TRAINS for tariffs; and WDI, WEF, and Doing Business for trade facilitation factors

Table C2.

	Baseline No Tariff		Baseline Importer		Importer and Exporter	
	Outcome	Selection	Outcome	Selection	Outcome	Selection
Ln(Border_Transp_Effic_i)	0.0192	0.217			0.425	-0.135
	[0.0410]	[0.0235]***			[0.049]***	[0.037]***
Ln(Business_ Env_i)	0.168	-0.0369			0.667	0.55
	[0.0299]***	[0.0274]			[0.063]***	[0.029]***
Ln(ICT_i)	0.0684	0.0621			0.157	-0.328
	[0.0354]*	[0.0263]**			[0.051]***	[0.033]***
Ln(Infrast_i)	0.463	0.167			0.927	-0.206
	[0.0446]***	[0.0378]***			[0.073]***	[0.045]***
Ln(GDP_i)	1.077	0.325			0.699	0.247
	[0.0137]***	[0.0133]***			[0.028]***	[0.016]***
Ln(Population_i)	0.135	0.0636			0.818	0.326
	[0.0141]***	[0.0132]***			[0.025]***	[0.013]***
Landlocked_i	-0.162	-0.191				
	[0.0340]***	[0.0289]***				
Ln(Distance_ij)	-1.119	-0.368	-1.303	-0.49	-0.659	-0.305
	[0.0177]***	[0.0226]***	[0.0164]***	[0.0250]***	[0.034]***	[0.030]***
RTA_{ij}	0.453	0.866	0.421	0.784	-0.373	0.829
	[0.0371]***	[0.100]***	[0.0329]***	[0.103]***	[0.091]***	[0.140]***
Border	1.063	-0.108	0.57	-0.112	1.359	-0.082
	[0.0716]***	[0.152]	[0.0696]***	[0.169]	[0.115]***	[0.220]
Common_Language	0.567	0.512	0.562	0.549	-0.037	0.532
	[0.0363]***	[0.0419]***	[0.0345]***	[0.0467]***	[0.070]	[0.060]***
Colonial_Relationship	0.463	-0.706	0.796	-0.318	0.943	-0.553
	[0.0587]***	[0.157]***	[0.0573]***	[0.172]*	[0.102]***	[0.183]***
Common_Colonizer	0.95	0.0787	0.923	0.0208	0.992	-0.045
	[0.0567]***	[0.0450]*	[0.0542]***	[0.0475]	[0.095]***	[0.067]
Ln(Border_Transp_Effic_j)			-0.00457	-0.166	-0.073	0.222
			[0.0293]	[0.0280]***	[0.066]	[0.030]***
Ln(Business_ Env_j)			0.162	0.606	0.208	-0.062
			[0.0300]***	[0.0262]***	[0.050]***	[0.034]*
Ln(ICT_j)			-0.167	-0.318	-0.08	0.059
			[0.0292]***	[0.0270]***	[0.053]	[0.030]**
Ln(Infrast_j)			0.486	-0.269	0.378	0.188
			[0.0409]***	[0.0366]***	[0.075]***	[0.049]***
Ln(1+Tariff_ij)			-3.195	-1.027	-1.574	-0.665
			[0.213]***	[0.119]***	[0.350]***	[0.166]***
Ln(GDP_j)			0.86	0.462	0.337	0.422
			[0.0123]***	[0.0125]***	[0.037]***	[0.016]***
Ln(Population_j)			0.182	0.00247	0.501	0.436
			[0.0127]***	[0.0128]	[0.033]***	[0.014]***
Landlocked_j			-0.338	0.0542	0.05	-0.177
			[0.0301]***	[0.0282]*	[0.059]	[0.040]***
Entry _Cost_ij		-0.155		-0.105		-0.109
		[0.0465]***		[0.0437]**		[0.056]*
Constant	-3.506	-3.085	-1.369	-4.126	-13.235	-13.179
	[0.303]***	[0.329]***	[0.313]***	[0.319]***	[1.111]***	[0.505]***
Observations	40400	40400	40400	40400	40400	35762

All regressions include time and importer fixed effects. Robust standard errors are in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Source: Authors' calculations based on data from COMTRADE for trade flows; TRAINS for tariffs; and WDI, WEF, and Doing Business for trade facilitation factors

Table C3. Estimates on different samples.

	(1) Fuels	(2) Ores and Metals	(3) Manufactures	(4) Textiles	(5) South-North	(6) South-South
	(Outcome)	(Outcome)	(Outcome)	(Outcome)	(Outcome)	(Outcome)
Ln(Border_Transp_Effic_i)	3.783	0.367	0.174	0.626	0.0387	-0.0204
	[1.059]***	[0.217]*	[0.0537]***	[0.0568]***	[0.0486]	[0.0490]
Ln(Business_ Env_i)	-0.122	0.332	0.0226	-0.0108	0.0934	0.240
	[0.336]	[0.122]***	[0.0514]	[0.0522]	[0.0464]**	[0.0424]***
Ln(ICT_i)	1.583	-0.340	0.0436	0.104	-0.0971	-0.214
	[0.683]**	[0.141]**	[0.0637]	[0.0766]	[0.0504]*	[0.0499]***
Ln(Infrast_i)	3.186	1.521	0.205	0.453	0.442	0.530
	[0.631]***	[0.363]***	[0.0890]**	[0.0907]***	[0.0693]***	[0.0651]***
Ln(1+Tariff_ij)	-0.367	-0.324	-0.0213	0.00796	-0.0811	-1.883
	[0.0888]***	[0.0757]***	[0.00392]***	[0.0135]	[0.352]	[0.266]***
Ln(GDP_i)	1.729	0.745	0.859	0.424	1.195	1.207
	[0.356]***	[0.0871]***	[0.0991]***	[0.0239]***	[0.0262]***	[0.0246]***
Ln(Population_i)	0.117	0.0625	-0.116	0.236	0.0356	0.148
	[0.136]	[0.0529]	[0.0219]***	[0.0451]***	[0.0255]	[0.0229]***
Landlocked_i	1.974	-0.0190	-0.198	0.0224	-0.344	-0.159
	[0.632]***	[0.142]	[0.0640]***	[0.0618]	[0.0591]***	[0.0571]***
Ln(Distance_ij)	-2.209	-0.906	-0.888	-0.733	-1.023	-1.289
	[0.354]***	[0.0774]***	[0.100]***	[0.0494]***	[0.0344]***	[0.0331]***
RTA_{ij}	0.754	-0.350	0.557	-0.0372	-0.163	1.241
	[0.359]**	[0.331]	[0.196]***	[0.125]	[0.0764]**	[0.0750]***
Border	-3.503	-0.768	0.735	0.139	1.007	1.033
	[1.293]***	[0.589]	[0.373]**	[0.229]	[0.240]***	[0.107]***
Common_Language	1.031	0.966	0.317	0.348	0.125	0.710
	[0.452]**	[0.246]***	[0.0916]***	[0.0822]***	[0.0783]	[0.0654]***
Colonial_Relationship	-0.512	0.458	0.372	-0.284	0.890	0.0400
	[0.798]	[0.419]	[0.486]	[0.320]	[0.148]***	[0.217]
Common_Colonizer	1.234	0.857	0.600	0.640	0.610	1.031
	[0.516]**	[0.212]***	[0.0962]***	[0.0899]***	[0.112]***	[0.0771]***
Constant	-36.10	-13.02	-2.217	-4.060	-6.742	-7.549
	[9.266]***	[3.958]***	[0.850]***	[0.962]***	[0.515]***	[0.558]***
Observations	40400	40400	40400	40400	8832	18768

All regressions include time and importer fixed effects. Robust standard errors are in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Source: Authors' calculations based on data from COMTRADE for trade flows; TRAINS for tariffs; and WDI, WEF, and Doing Business for trade facilitation factors.

Appendix D

Derivation of the gravity model adapted from Helpman, Melitz and Rubinstein (2008)

D1. Model set-up

In this section we describe the structural model adapted from Helpman, Melitz, and Rubinstein (henceforth, HMR) (2008). HMR develop a simple model of international trade with heterogeneous firms that is consistent with a number of stylized features of the data. In particular, the model predicts positive as well as zero trade flows across pairs of countries, and it allows the number of exporting firms to vary across destination countries. As a result, the impact of trade frictions on trade flows can be decomposed into the intensive and extensive margins, where the former refers to the trade volume per exporter and the latter refers to the number of exporters. This model yields a generalized gravity equation that accounts for the self-selection of firms into export markets and their impact on trade volumes.

HMR use their conceptual framework to develop a two-stage estimation procedure that generalizes the empirical gravity equation by taking into account the extensive margin (the decision to export from j to i), and the intensive margin (the volume of exports from j to i, conditional on exporting). The first stage consists of a probit regression that models the probability that country j exports to country i. The second stage is a gravity equation estimated in logarithmic form. This two-stage procedure aims at correcting for two potential problems present in estimations of the gravity equation. First, a standard selection bias may result from dropping observations with zero trade when estimating gravity models in logarithmic form. The second bias is due to the potential unobserved firm level heterogeneity resulting from an omitted variable that measures the impact of the number of exporting firms (the extensive margin).

Consider county j producer of product l has the input coefficient a and it sells its product in the home market, the home market consumer pays $p_j(l) = c_j a/\alpha,$ where α is the elasticity of demand. If, however, it sells the product in a foreign country i, the consumers in i are charged $p_i(l) = \tau_{ij} c_j\, a/\alpha$, where τ_{ij} is the bilateral trade costs between i and j. As a result, the producer's operating profits from selling in country i are

$$\pi_{ij}(a) = (1-\alpha)\left(\frac{\tau_{ij}c_j a}{\alpha P_i}\right)^{1-\varepsilon} Y_i - c_j f_{ij}.$$

Evidently, these operating profits are positive for sales in the domestic market, because the fixed cost of serving country i, $f_{jj} = 0$. Therefore all N_j producers sell in country j. But sales in country $i \neq j$ are profitable only if $a \leq a_{ij}$, where a_{ij} is defined by $\pi_{ij}(a_{ij}) = 0$, or

$$(1-\alpha)\left(\frac{\tau_{ij}c_j a_{ij}}{\alpha P_i}\right)^{1-\varepsilon} Y_i = c_j f_{ij}. \tag{1}$$

It follows that only a fraction $G(a_{ij})$ of country j's N_j firms export to country i. In particular, no firm from country j exports to country i if a_{ij} is smaller than a_L i.e., if the least productive firm that can profitably export to country i has a coefficient a that is below the support of $G(a)$. If a_{ij} were larger than a_H, then all firms from country j would export to i.

It follows from the zero profit condition that bilateral trade volumes will be given by:

$$V_{ij} = \begin{cases} \int_{aL}^{a_{ij}} a^{1-\varepsilon}\, dG(a) & \text{for } a_{ij} \geq a_L \\ 0 & \text{otherwise.} \end{cases} \tag{2}$$

The value of imports by country i from country j will be

$$M_{ij} = \left(\frac{c_j \tau_{ij}}{\alpha P_i}\right)^{1-\varepsilon} Y_i N_j V_{ij}. \tag{3}$$

Equation (3) provides a mapping from the income levels Y_i, the numbers of firms N_i, the unit costs c_i, the fixed costs f_{ij}, and the transport costs τ_{ij}, to the bilateral trade flows M_{ij}. Trade costs (τ_{ij}) affect the volume of firm-level exports. These costs are stochastic due to i.i.d. unmeasured trade frictions u_{ij}, which are country-pair specific. In particular, let $\tau_{ij}^{\varepsilon-1} \equiv D_{ij}^{\gamma} e^{-u_{ij}}$, where γ is a parameter, D_{ij} is function of the vectors of infrastructure in the exporter and importer countries (INF_i, INF_j), as well as a vector of exporter-importer pair characteristics, denoted T_{ij} , such as distance. Assuming a linear form, we can write: $D_{ij} = \varsigma_i INF_i + \varsigma_j INF_j + T_{ij}$ (4)

Direct estimation of equation (3) would require information about a_{ij} and a_L, which is typically not available. To overcome this problem, HMR define the latent variable

$$Z_{ij} = \frac{(1-\alpha)(P_i \dfrac{\alpha}{c_j \tau_{ij}})^{\varepsilon-1} Y_i a_L^{1-\varepsilon}}{c_j f_{ij}} \tag{5}$$

The new variable Z_{ij} is not observed. However, positive trade is observed when $Z_{ij} > 1$, which leads HMR to propose the following two-step estimation strategy. Let T_{ij} be a binary indicator defined as $T_{ij} = 1[M_{ij} > 0]$ and let ρ_{ij} be the probability that j exports to i, conditional on the observed variables and specify the following Probit equation:

$$\begin{aligned} \rho_{ij} &= \Pr(T_{i,j} = 1 \mid observed \quad variables) \\ &= \Phi[\gamma_0 - \gamma d_{ij} + (\phi_{EX,j} - \varepsilon \ln c_j) + [(\varepsilon-1) p_i + y_i - \phi_{IM,i}] - \kappa \varphi_{ij} + \eta_{ij}] \end{aligned} \tag{6}$$

where $\Phi(\cdot)$ is the cumulative distribution function of the unit-normal distribution and where lowercase variables represent the natural logarithms of their respective uppercase variables.. Importantly, this selection equation has been derived from a firm-level decision, and it, therefore, does not contain unobserved firm endogeneity that is related to the fraction of exporting firms.

Let $\hat{\rho}_{ij}$ be the predicted probability of exports from j to i, using the estimates from the Probit equation (6), and let $\hat{z}_{ij}^{*} = \Phi^{-1}(\hat{\rho}_{ij})$ be the estimated latent variable

$z_{ij}^* \equiv z_{ij} / \sigma_\eta$. Since η_{ij} has a unit Normal distribution, a consistent estimate $\hat{\eta}_{ij}^*$ is obtained from the inverse Mills ratio.[28] The use of $\hat{\eta}_{ij}^*$ to control for E [u_{ij} | ., T_{ij}= 1] is the standard Heckman (1979) correction for sample selection. The Heckman correction addresses the biases generated by the unobserved country-pair level shocks u_{ij} and η_{ij}, but it does not correct for the biases generated by the underlying unobserved firm-level heterogeneity. The latter biases are corrected by the additional control $\hat{z}_{ij}^*$.

With the information learned about a_{ij} and a_L from the estimation of the latent variable z_{ij} we now can accurately estimate equation (3). Taking logs of equation (3) and using the appropriate correction variables estimated from equation (6) (i.e., $\hat{z}_{ij}^*$ and $\hat{\eta}_{ij}^*$) results in the trade equation to be estimated

$$m_{ij} = \beta_0 + \lambda_j + \chi_i - \gamma d_{ij} + \delta \hat{z}_{ij}^* + \beta_{u\eta} \hat{\eta}_{ij}^* + e_{ij} \tag{7}$$

This gravity equation takes into account the important effect of trade barriers and country characteristics on the share of exporting firms. The outcome equation incorporates information of the selection equation through the inverse mills ratio as well as the zeta and zeta equation that are computed from estimates of the selection equation.

D2. Importance of Firm Heterogeneity

In this section we empirically confirm the importance of both correction terms derived from the Helpman Melitz & Rubinstein (HMR) (2008) model described in the article. For this, we replicate Table IV of MHR (2008) where the authors test the importance of each correction term individually.

The results are reported in Table D1 below. The first column reports the first stage selection stage. Column 2 reports the baseline estimation where both firm heterogeneity and zero trade have been corrected whereas Column 3 reports the estimation where none of the correction term is included. The differences in the estimated coefficients of these two equations represent the joint outcome of the two biases. All the coefficients of the traditional gravity model, with the exception of the land border effect, are lower in absolute value in the second column. We then implement the correction for unobserved heterogeneity by adding *zeta* and *zeta_sq* as additional regressors to the standard gravity specification (here, we do not correct for the sample selection). The results reported in the fourth column clearly show that this unobserved heterogeneity (the proportion of exporting firms) addresses almost all the biases in the standard gravity equation. The coefficients and standard errors for all the observed trade barriers are very similar to those obtained in our baseline estimation where both effects have been corrected for.

In the last column, we correct only for the selection bias (the standard two-stage Heckman (1979) selection procedure) by introducing the inverse mills ration (*mills*) as an additional regressor. Although the estimated coefficient for *mills* is significant the remaining coefficients are very similar to those obtained in the non-corrected specification of column (2).

Table D1. Importance of HMR correction terms

	1	2	3	4	5
	Selection	**Baseline**	**No Correction**	**Firm heterogeneity**	**Heckman Selection**
Ln(Border_Transport_Effic_i)	0.262	0.068	0.187	0.065	0.122
	[0.032]***	[0.065]*	[0.065]***	[0.065]*	[0.064]*
Ln(Business_ Environment_i)	-0.054	0.149	0.106	0.155	0.143
	[0.034]	[0.047]***	[0.048]**	[0.047]***	[0.048]***
Ln(ICT_i)	0.066	0.011	0.073	0.004	0.014
	[0.032]**	[0.051]	[0.051]	[0.051]	[0.051]
Ln(Phys_ Infrastruct_i)	0.207	0.497	0.614	0.492	0.552
	[0.050]***	[0.071]***	[0.072]***	[0.071]***	[0.072]***
Ln(1+Tariff_ij)	-0.196	-1.304	-1.325	-1.276	-1.273
	[0.208]	[0.346]***	[0.348]***	[0.345]***	[0.342]***
Ln(GDP_i)	0.3	0.862	1.013	0.867	0.951
	[0.017]***	[0.023]***	[0.022]***	[0.023]***	[0.022]***
Ln(Population_i)	0.09	0.168	0.213	0.17	0.195
	[0.017]***	[0.023]***	[0.023]***	[0.023]***	[0.023]***
Ln(Distance_ij)	-0.331	-0.899	-1.042	-0.896	-0.976
	[0.032]***	[0.032]***	[0.032]***	[0.032]***	[0.032]***
RTA_ij	0.799	0.332	0.455	0.341	0.488
	[0.148]***	[0.068]***	[0.068]***	[0.068]***	[0.066]***
Landlocked_i	-0.199	-0.097	-0.214	-0.099	-0.147
	[0.041]***	[0.056]*	[0.058]***	[0.056]*	[0.057]***
Border	-0.112	1.225	1.173	1.24	1.199
	[0.237]	[0.121]***	[0.142]***	[0.122]***	[0.131]***
Common_Language	0.559	0.342	0.736	0.359	0.558
	[0.060]***	[0.067]***	[0.066]***	[0.067]***	[0.066]***
Colonial_Relationship	-0.732	0.538	0.329	0.544	0.419
	[0.148]***	[0.099]***	[0.113]***	[0.100]***	[0.105]***
Common_Colonizer	0.088	0.968	0.99	0.961	0.967
	[0.067]	[0.096]***	[0.098]***	[0.096]***	[0.097]***
mills		3.33			-1.862
		[0.387]***			[0.147]***
zeta		2.816		1.226	
		[0.185]***		[0.068]***	
zeta_sq		-0.362		-0.126	
		[0.027]***		[0.011]***	
entry_cost	-0.129				
	[0.061]**				
Constant	-4.68	-5.697	-6.326	-3.112	-3.424
	[0.418]***	[0.623]***	[0.516]***	[0.549]***	[0.562]***
Observations	40400	35762	35762	35762	35762
R-squared		0.76	0.75	0.76	0.76

All regressions include time and importer fixed effects. Robust clustered (by country pairs) standard errors are in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix E

Using one-step principal components procedure to obtain alternative indicators

To evaluate our procedure to derive the indicators, we derive alternative four indicators by applying one-step principal components procedure analogous to Francois and Manchin (2007) to our larger set of primary variables. Indeed, we apply principal components and retain two components for hard infrastructure and two components for soft infrastructure. Then, we include these four alternative indicators on our baseline specification instead of our indicators, coefficients estimates for the two alternative indicators are negative and significant, whereas it is only positive and significant for one of the two alternative hard infrastructure indicators, as shown below in Table D1. This is evidence that our procedure based deals better with a larger set of indicators that can be more correlated by producing indicators that are less correlated and keep explanation power vis-à-vis bilateral trade

Table E1

	outcome equation	selection equation
	1	2
ln(hard_inf 1)	-0.007	0.076
	[0.025]	[0.023]***
ln(hard_inf 2)	0.19	0.054
	[0.013]***	[0.011]***
ln(hard_inf 1)	-0.05	-0.064
	[0.014]***	[0.015]***
ln(hard_inf 2)	-0.029	0.059
	[0.009]***	[0.007]***
Ln(GDP_i)	1.126	0.37
	[0.012]***	[0.012]***
Ln(Population_i)	-0.016	0.024
	[0.012]	[0.012]**
Ln(1+Tariff_ij)	-1.311	-0.26
	[0.187]***	[0.165]
Landlocked_i	-0.265	-0.3
	[0.032]***	[0.028]***
Ln(Distance_ij)	-1.006	-0.356
	[0.019]***	[0.024]***
RTA_ij	0.543	0.793
	[0.041]***	[0.085]***
Border	1.106	-0.171
	[0.075]***	[0.144]
Common_Language	0.505	0.544
	[0.039]***	[0.045]***
Colonial_Relationship	0.506	-0.73
	[0.084]***	[0.184]***
Common_Colonizer	0.955	0.098
	[0.051]***	[0.044]**
entry_cost		-0.157
		[0.046]***
Constant	-2.061	-3.316
	[0.313]***	[0.334]***
Observations	40400	40400

Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

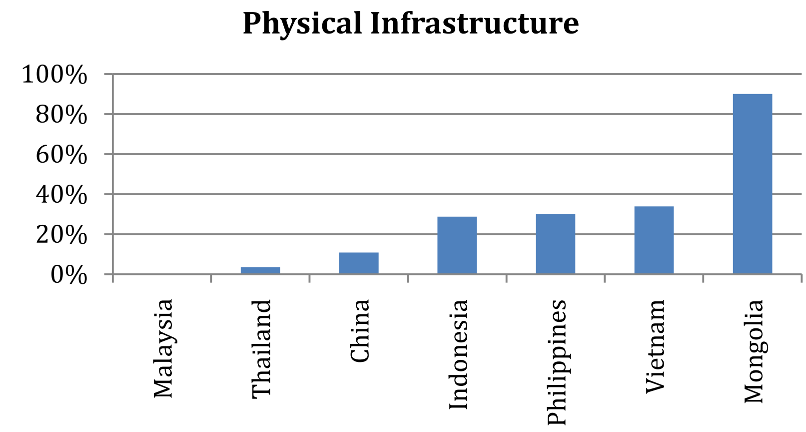
Appendix F.

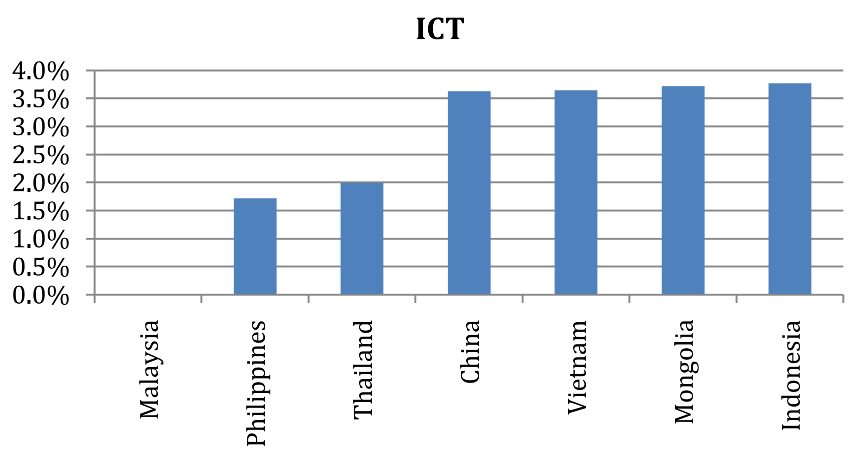
Simulation Results for all indicators

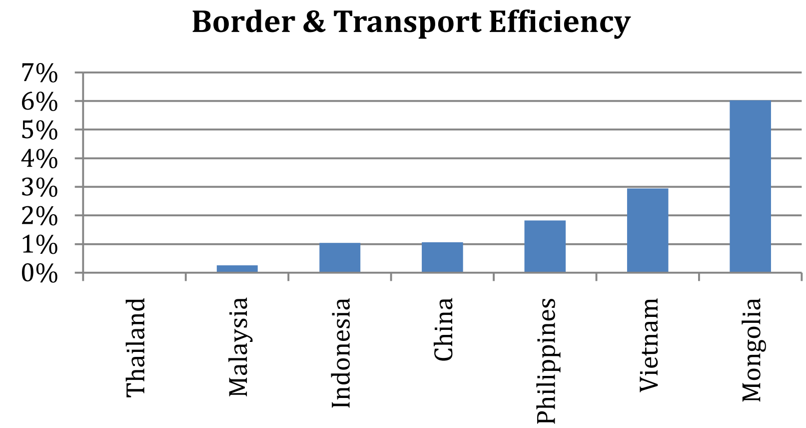
To illustrate the analysis, we briefly discuss the simulation results for selected countries with the lowest performance in each region. The figures are at the end of the Appendix.

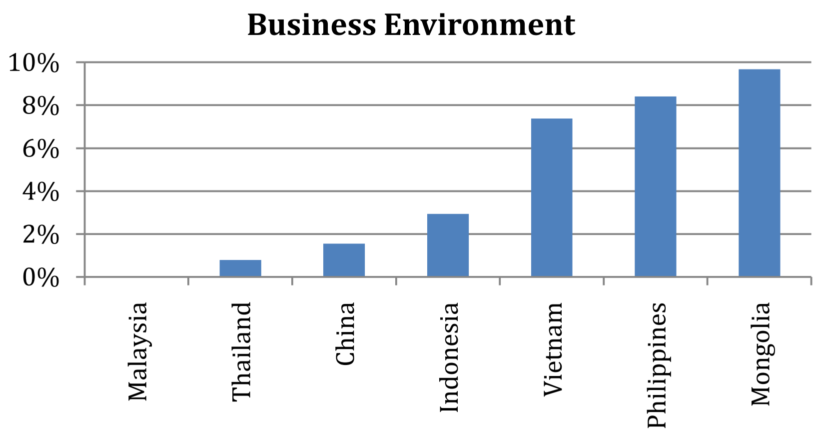
In all regions investment in physical infrastructure quality halfway to the top performer will result in great gains, as measured by a high ad-valorem equivalent. In addition, it is worth mentioning the importance of regional characteristics for policy decision making. For instance, improvements in infrastructure in Sub-Saharan African countries would generate an important increase in trade flows, whereas for some South Asian countries, investment in improving the business environment would generate the greatest return. In most regions, improved border and transport efficiency to the benchmark is associated with lower exports growth as the estimated elasticity of this indicator on exports is the lowest among four indicators. Furthermore, countries of these regions are not so heterogeneous along this indicator.

a. East Asia and Pacific.



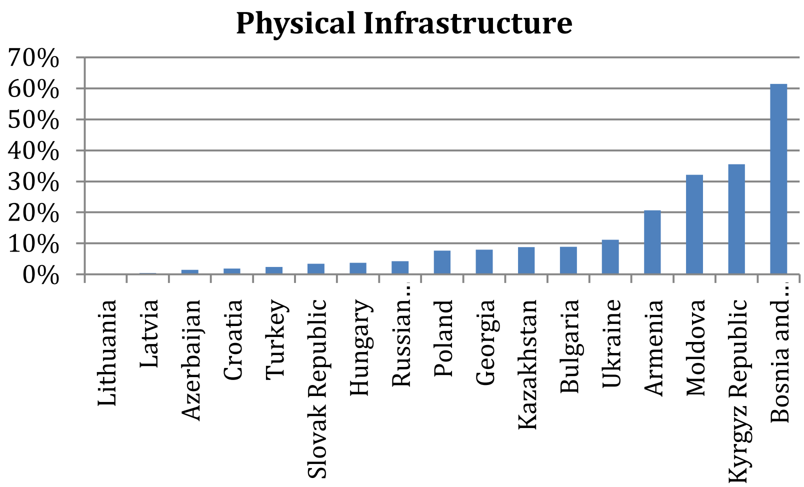


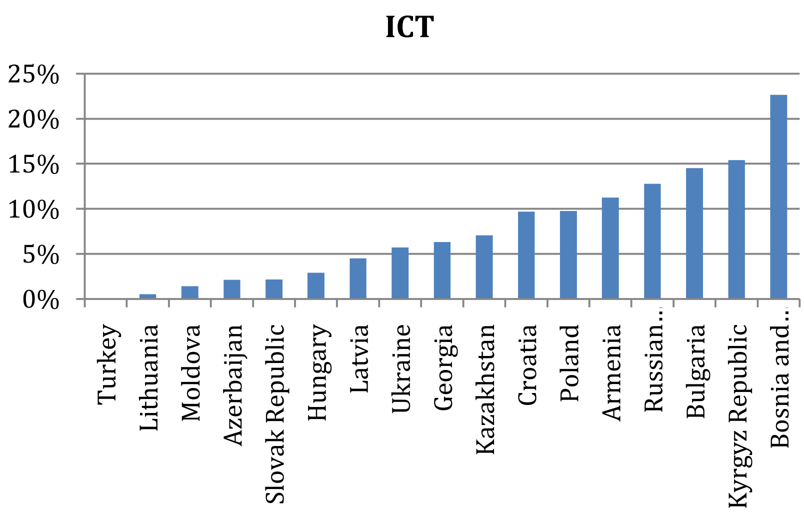


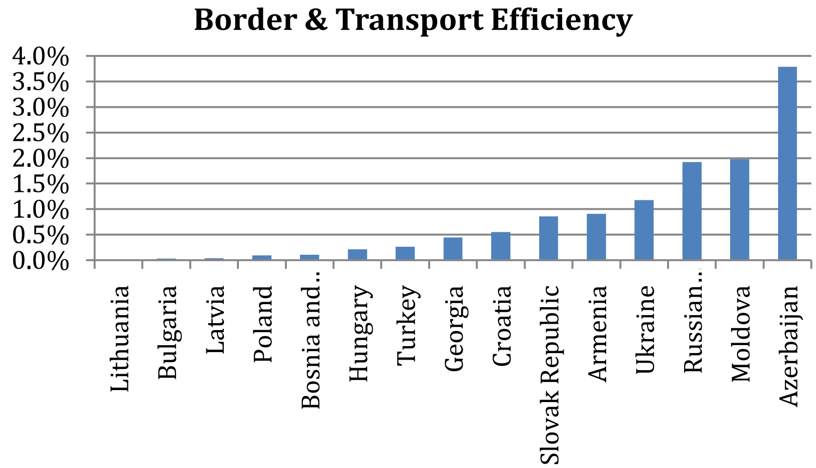


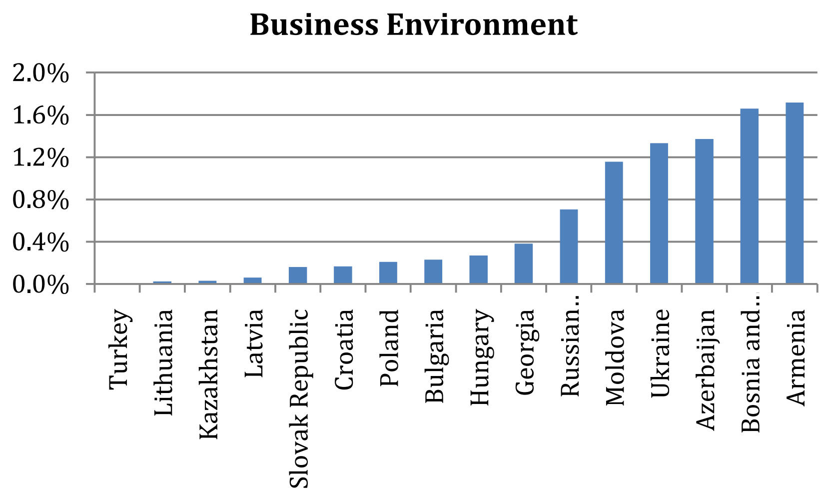
Source: Authors' calculations.

b. Europe and Central Asia



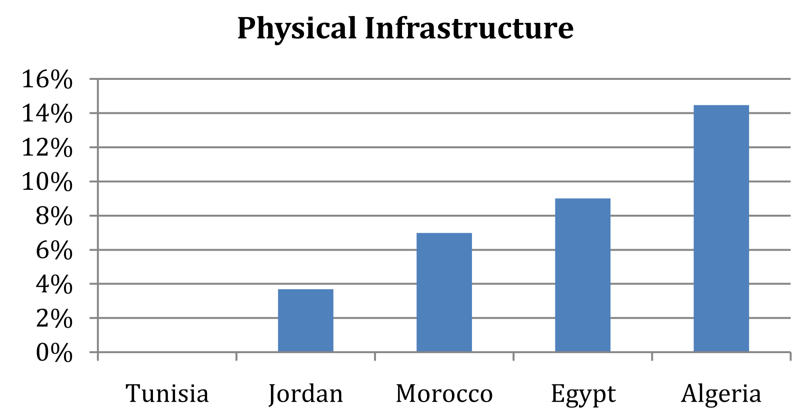


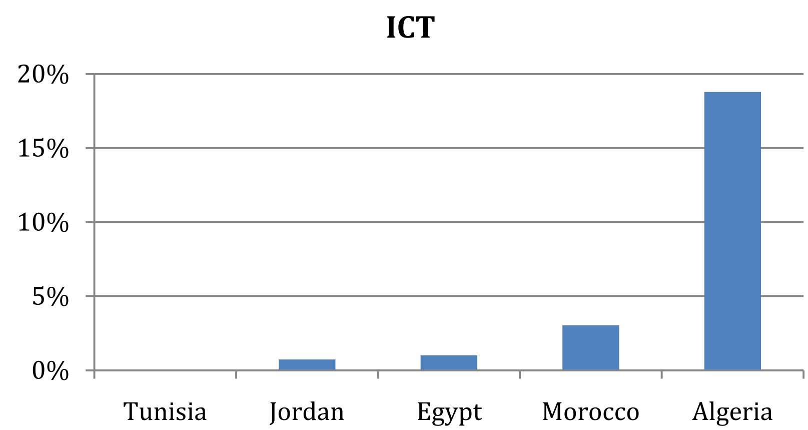


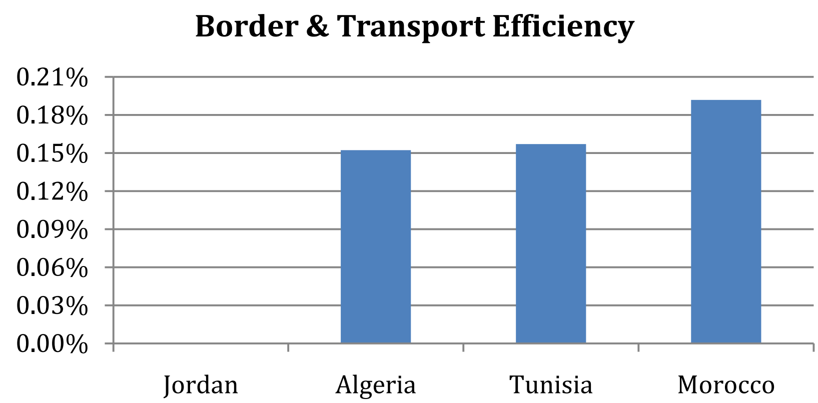


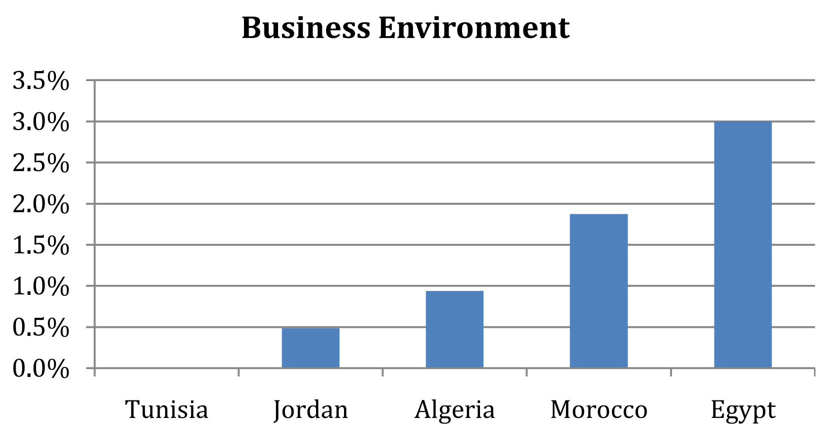
Note: Kazakhstan and Kyrgyztan have corresponding values of 42% and 50% in Border and Transport Efficiency. Kyrgyztan has a corresponding value of 100 % in business environment. They are not represented in the graphs due to scale differences.
Source: Authors' calculations.

c. **Middle East and North Africa**



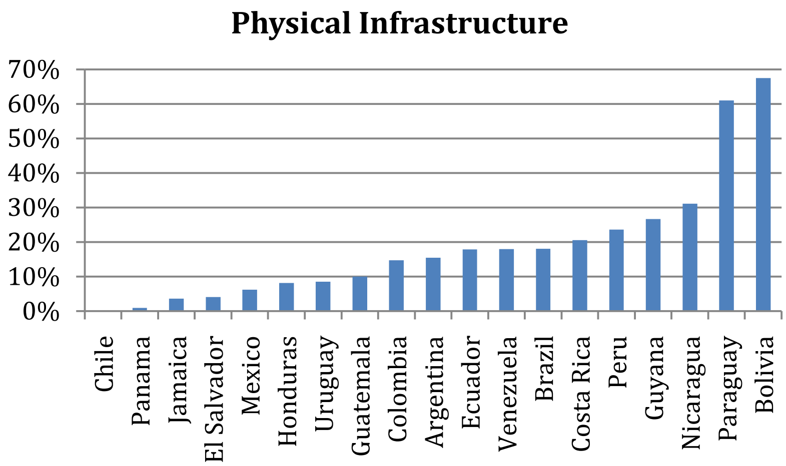


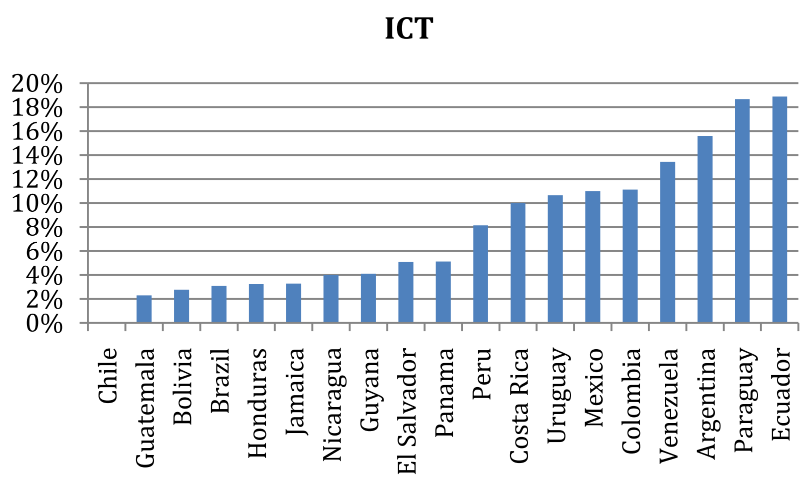




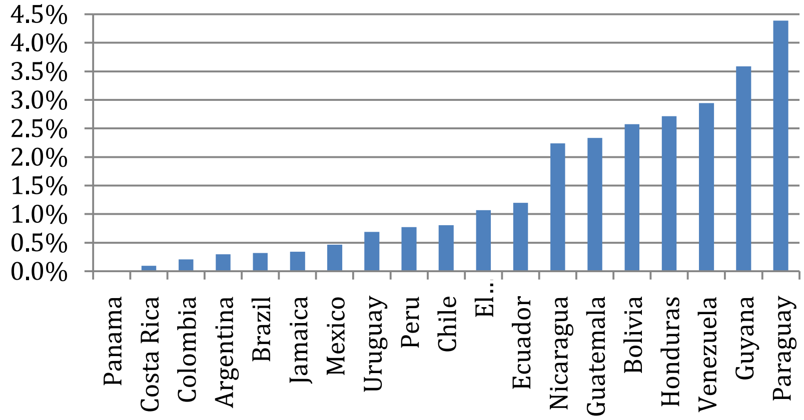
Source: Authors' calculations.

d. Latin America and the Caribbean

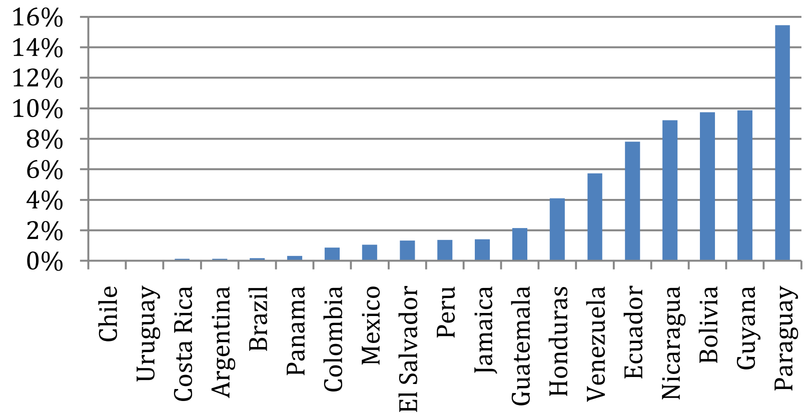




Border & Transport Efficiency

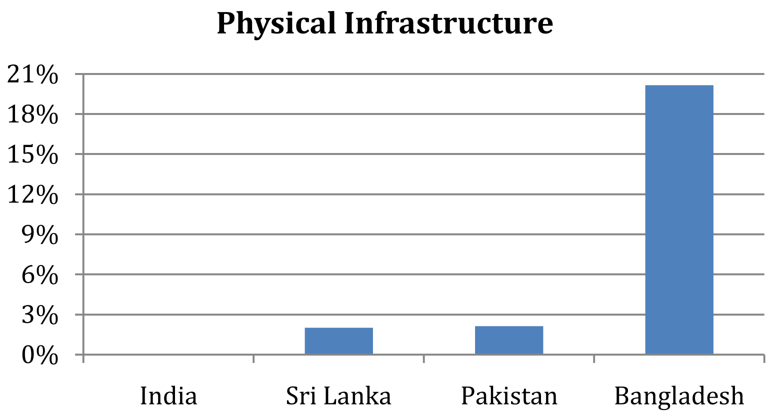


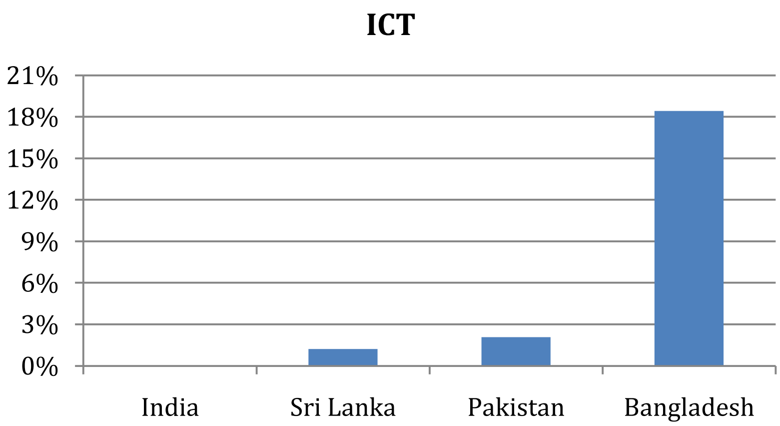
Business Environment

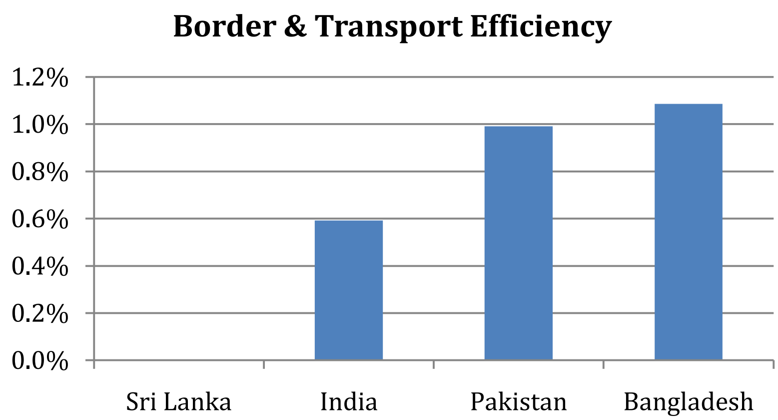


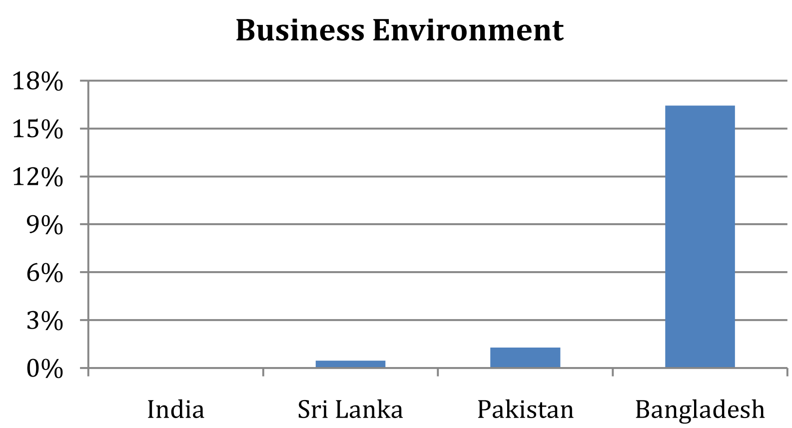
Source: Authors' calculations.

e. South Asia


Physical Infrastructure
21%
18%
15%
12%
9%
6%
3%
0%
India
Sri Lanka
Pakistan
Bangladesh

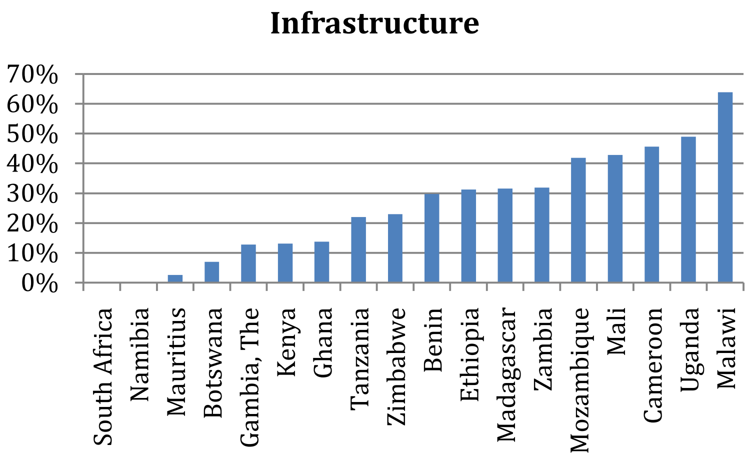

ICT
21%
18%
15%
12%
9%
6%
3%
0%
India
Sri Lanka
Pakistan
Bangladesh

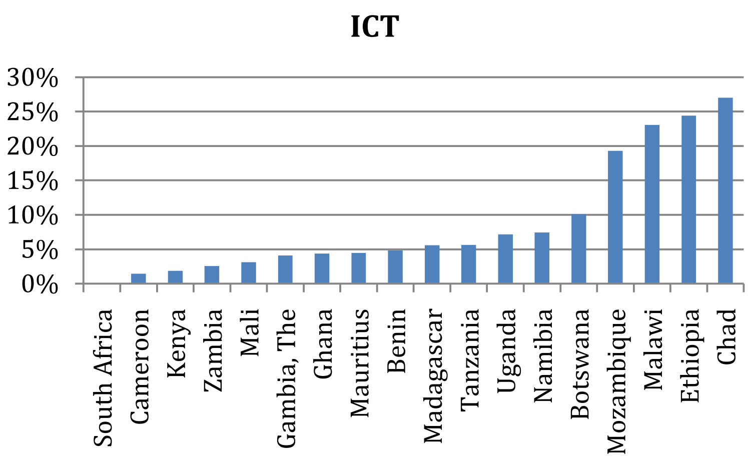


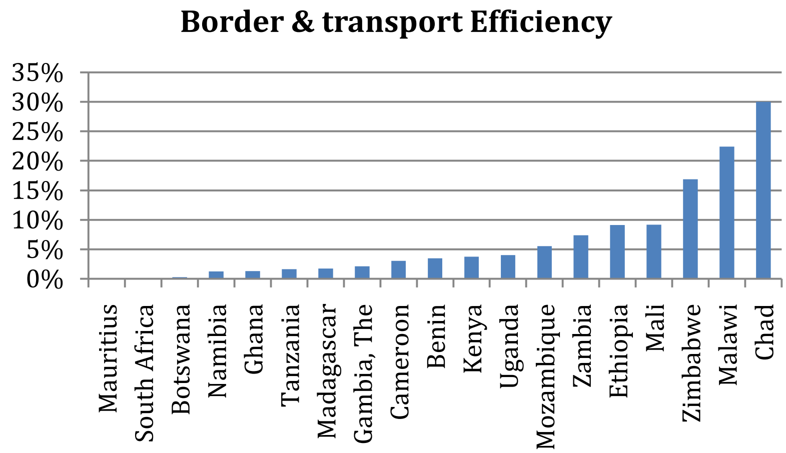


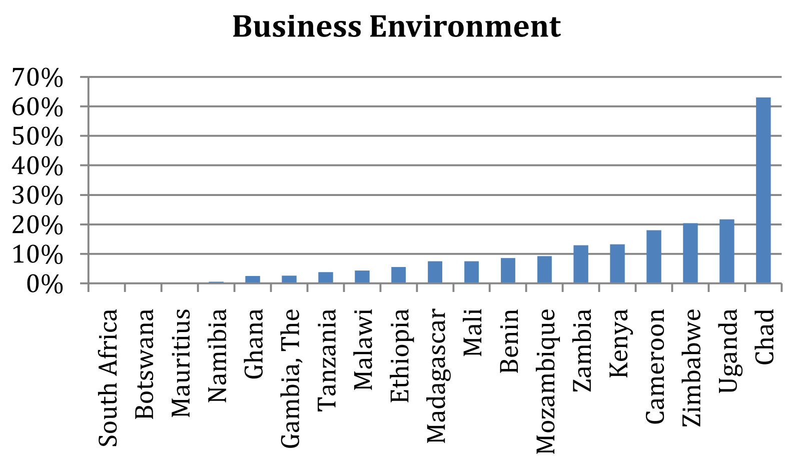
Source: Authors' calculations.

f. Sub-Saharan Africa









Note: Chad has a corresponding value of 112% in physical infrastructure and Zimbabwe has a corresponding value of 59% in Business Environment. They are not represented in the graphs due to scale differences.

Source: Authors' calculations.