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The impacts of institutional quality and infrastructure on overall and intra-Africa trade

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Abstract

The authors examine the impacts of quality of institutions, border and transport efficiency, physical and communication infrastructure on overall and intra-Africa trade covering 44 African countries and their 173 trade partners for the periods 2000–2014. Aggregate indicators are derived for the quality of economic institutions, border and transport efficiency, physical and communication infrastructure using principal component analysis. The findings disclose that intra-Africa and overall Africa's trade robustly determined by the quality of institutions, border and transport efficiency, physical and communication infrastructure. The estimates also indicate that the marginal effect of the quality of institutions, physical and communication infrastructure on trade flow appears to be increasing in GDP per capita. In contrast, the marginal effect of border and transport efficiency on trade decreases in GDP per capita. The authors compute the simulation of improving each indicator to the best performer in the sample. Their findings are robust to estimation method conducted to account for potential endogeneity.

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Keywords Trade flow; transport and border efficiency; quality of institutions; physical and communication infrastructure; gravity model; African countries

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1 Introduction

In contemporary economics literature international trade is considered as one of the major factors positively contributing for economic growth and development (Andersen and Babula, 2008; Matthias and Jens, 2012; Mercan et al., 2013). In this path, however, African countries have traditionally lagged the rest of the world (Portugal-Perez and Wilson, 2008; Assane and Chiang, 2014).African countries are among those having the least trade share compared to other regions in the world market (Assane and Chiang, 2014). Its share of global trade is also limited to 3.2% (United Nations Economic Commission for Africa, 2012). Similarly, intra-Africa trade is relatively the lowest compared to other regions. According to the World Bank statistics it was 11% of the continent's total trade between 2007 and 2011 compared to that of other developing regions such as intra-Latin America trade that amounts more than 20% and trade within Asian developing countries that represent 48% (Ancharaz et al., 2011).

Furthermore, based on WTO (2017) report trade within the European Union (EU), North American Free Trade Agreement ((NAFTA), Association of South Asian Nations (ASEAN) and South Common Market (MERCOSUR) was represented by 63%, 50%, 24% and 14%, respectively. Among regional economic community in Africa, East African Community (EAC) has a relatively higher share of intra-trade registering 19.52% in 2013. In addition, South African Development Community (SADC), West African Economic and Monetary Union (WAEMU), Common Market for Eastern and Southern Africa (COMESA) and Economic Community of West African States (ECOWAS) have registered 18%, 14.73%, 9.42% and 9.32% intra-regional trade, respectively (Geda and Seid, 2015). Therefore, compared to other regions Africa's regional economic communities have relatively low performance in intra-regional trade andover 80% of Africa's exports are still destined for markets outside Africa (Geda and Seid, 2015).

Some literature indicates that tariff and non-tariff barriers are responsible for the high cost of trade and the lower performance of developing countries in the world trade (OECD, 2005; Linders et al., 2008). However, recently non-tariff barriers have relatively higher impacts on trade performance of countries because tariffs on international trade are generally becoming lower as countries have been progressively liberalized joining World Trade Organization (WTO), and regional and bilateral trade agreements (United Nations Conference on Trade and Development, 2013; WTO, 2012).

In most African countries transport cost incidence for exports is five times higher than tariff cost incidence (World Bank, 2001). That is the effect of tariff cost is relatively becoming less important, while non-tariff factors, such as regulatory barriers, business environment, infrastructure, institutional quality, and economic freedom are becoming major determining factors of trade flow.

Recent empirical literature suggests that improvement in border and transport efficiency, institutional quality and infrastructure can have a robust effect on the trade performance of countries. For example, employing gravity model Francois and Manchin (2013) argue that infrastructure and institutional quality indicators affect the patterns of trade. However, they did not consider border and transport efficiency indicators in their specification and their study was also limited to time periods 1990–2003. Similarly, using gravity estimation Portugal-Perez and Wilson (2012) find that the aggregate indicators of hard and soft infrastructure have an effect on

the export performance of developing countries over the period 2004–2007. Assane and Chiang (2014) study trade reform policies and institutional quality for the Economic Community of West African States. Nonetheless, their study is limited to trade policies and institutional quality for data spanning 1984–2006.

Also employing a gravity model, Sonora (2008) estimate the effects of economic freedom on US consumer exports and imports for the years 2000 and 2005 and finds that better economic freedom of the partner country has a positive effect on the amount of exports from the United States. Hence empirical assessment of the impacts of non-tariff barriers of trade flow should take into account the business environment and infrastructure and institutional quality on the top of traditional determinants of trade flow.

In this paper, our aim is to examine the impact of economic institutional quality, border and transport efficiency, physical and communication infrastructure on trade flow of African countries and their participation in international and regional trade. We match bilateral trade flow of African countries with their trade partners to traditional gravity variables, physical and communication infrastructure, border and transport efficiency, governance and economic institutional quality indicators. Our results reveal that trade flow and the probability of African countries to take part in the intra-Africa and international trade depends on the quality of physical and communication infrastructure, border and transport efficiency, quality of economic and governance institutions of African countries.

This study is significant for a few reasons. First, it adds to the existing literatures by conducting comprehensive empirical study on the impact of physical and communication infrastructure, border and transport efficiency and quality of institutions of African countries relatively for longer time period (2000–2014) and covering bilateral trade flow data of 44 African countries (exporter) with 173 trade partners (importers). The longer period would help better capture the heterogeneity among countries when it comes to trade flows and trade facilitation measures (Seck, 2017). We also test the hypothesis for trade flow within African countries (intra-Africa trade). Second, On the top of physical and communication infrastructure in which more attention has traditionally given, we thoroughly examine the impact of border and transport efficiency indicators and quality of institutions using a wide range of economic and governance indicators. We control economic institutions which have greater coverage than previous indicators and a more recent one that can show business regulation, property rights and legal enforcement, sound money and governance institutions. Third, we employ two-step Heckman (1979) sample selection model to deal with a potential bias due to unobserved heterogeneity and a sample selection problem as there is 30% zero valued observations in the sample. Applying this method, we examine the impact of these indicators on the probability to trade (extensive margin) and bilateral trade flow (intensive margin), avoiding any bias involved because of omission of the extensive margin. Fourth, we take into account omitted multilateral resistance effects adjusting for bilateral trade cost variables. Fifth, our model incorporates interaction terms between these indicators and per capita GDP of African countries, and we also conduct counterfactual analysis to the best-performing economy for each of our target variables. Finally, we run robustness check for endogeneity concern running IV method using legal origin, civil liberty, government fractionalization, check and balance and lagged values of time-varying explanatory variables. In addition, we run pseudo-maximum likelihood estimator (PPML) to assess the consistency of the results. As these tests disclose our results are proven to be robust.

The rest of this paper is organized as follows: Section 2 discusses the literature review. Section 3 explains the methodology of the study and data. Section 4 presents the results and findings of the study. Section 5 contains robustness check and counterfactual analysis. Section 6 presents conclusion and policy implications based on the findings.

2 Literature review

A number of empirical literatureanalyze the impact of different factors on trade flow and integration of countries. They tried to look at the impact of trade reform policies, transaction costs, quality and efficiency of infrastructure, logistics performance, economic status, cultural and geographical distance and political and institutional quality of countries and they find that these factors have a significant effect on bilateral trade flow of different countries. For instance, Wilson et al. (2005) evaluate four measures of trade facilitation: port facilities, customs handling, the regulatory environment and the availability of service sector infrastructure. Their results show that improvements in all four measures would have material impacts on both exports and imports. Furthermore, Djankovet al. (2010) use gravity equation to analyze the effect of time delays on international trade for 146 countries in 2005. Their findings reveal that, on average, each additional day a product is delayed prior to being shipped reduces trade by at least 1%. Persson (2008) assesses the potential effects of trade facilitation in the form of the time required to export and import on trade flow for 22 European Union countries using a sample selection approach. The results suggest that time delays on the part of the exporter and the importer significantly decrease trade flows. The result also reveals that, on average, lowering border delays in the exporting country by one day from the sample mean would yield an export-increasing effect of about 1%.

Similarly, Nordås et al. (2006) analyze the effect of time for exports and imports on international trade based on cross-sectional data for 140 countries in 2004 and find that time delays result in lower trade volumes and reduce the probability that firms will enter export markets for time-sensitive products. Iwanow and Kirkpatrick (2009) analyze the trade facilitation or reducing the transaction costs associated with the enforcement, regulation and administration of trade policies for a panel dataset of 124 developed and developing countries for the period 2003–04. Their results indicate that enhancing trade facilitation and other trade-related institutional constraints on manufacturing export performance could contribute to improving export performance in Africa.

Likewise, Djankov et al. (2010) use a difference gravity equation to solve the problem that most of the infrastructure variables do not have a bilateral dimension which is the variation in the data used to estimate gravity equations. They find that soft infrastructure does matter for international trade. An extra day on the number of days necessary to clear customs in the exporting country leads to a 1% reduction in exports. They also cleverly control for potential reverse causality. Indeed countries that rely more heavily on export markets may invest more on export infrastructure. In addition, Portugal-Perez and Wilson (2012) examine the impacts of hard and soft infrastructure on bilateral trade flows using gravity framework and controlling for different indices of physical, communication and transport efficiency infrastructure. Their

results indicate that physical infrastructure is the most robust determinant of bilateral exports, whereas the impact of other variables often changed signs depending on specifications or the estimators they used.

Ismail and Mahyideen (2015) analyze the effects of individual indicators of physical and soft infrastructure on the trade performance of Asian countries. This study quantifies the impacts of both hard and soft infrastructure on trade volume for exporters and importers in the region as well as on various economic growth indicators. Their results demonstrate that improvements in each transport infrastructure such as the road, air transport, railways, ports, and logistics enhance trade flow of Asian countries. Their results also show the impact of soft infrastructure on trade flows is robust.

Furthermore, the importance of information and communication infrastructure was also highlighted by some empirical studies. For example, the study by Bankole et al. (2015) examine the impact of information and communications technology infrastructure on intra-Africa trade using archival data from 28 African countries and find that information and communication infrastructure and institutional quality have a robust positive effect on intra-Africa trade. Their results suggest that institutional quality coupled with telecommunication infrastructure enhance efficiencies in intra-African trade flows. Also, a study by Ismail and Mahyideen (2015) show information and communications technology infrastructure has enhanced trade enhancement effect in Asian countries.

Using computable general equilibrium model Abe and Wilson (2008) conduct a study on the impact of improvement in institutional quality through reducing corruption and improving transparency to lower trade costs in the Asia Pacific Economic Cooperation region. Their findings infer that improvement in transparency and reducing corruption has a sound effect on trade flow and welfare gains for the region.

Furthermore, using a gravity model Francois and Manchin (2013) examine the impact of infrastructure and institutional quality on bilateral trade flows accounting zero valued trade observations as well as multilateral resistance term using the method proposed by Baier and Bergstrand (2009). They used the lagged values of time-varying explanatory variables to control for endogeneity of infrastructure and institutional quality. They found that institutional quality is important determinants of bilateral trade flow among countries. Similarly, using a gravity model Seck (2017) examines the extent to which various elements of the trade cost landscape in sub-Saharan Africa may have contributed to shaping trade patterns both within the region and with the outside world using different trade facilitation measures such as border efficiency, physical infrastructure, regulatory environment, information and communication technology, and logistics performance for 2007 and 2012.

Literature mentioned above examined the impact of infrastructure and institutional quality on the trade flow of different countries. However, a few studies have been conducted a comprehensive analysis on the impact of physical and communication infrastructure, border and transport efficiency and domestic institutional quality indicators on trade flow of African countries and probability to participate in world trade. In addition, studies conducted so far, however, are not sufficient, not without limitations in terms of their coverage and econometrics specification. Therefore, our study fills the gap by examining the impacts of different components of infrastructure, border efficiency and domestic institutional quality on the trade performance of African countries using robust econometric model.

3 Data and methodology

3.1 Data

Our study covers trade flow from 44 African countries to 173 trade partners for the periods 2000–2014. The period and the sample of African countries are bounded by the availability of data for important control variables. The list, definition of variables, the sources of data and the list of sample African countries and their trade partners considered in this study are given in Appendix A. The summary statistics of major variables is spelt in Table 8 in Appendix B. Trade flow is taken from Direction of Trade Statistics (DOTS) of IMF. We use trade inflow from African countries to their trade partners as it is more suitable for gravity model approach. Facts of the explanatory variables of our interest are spelt out in the following part.

Quality of institutional indicator

The empirical analysis for this paper utilizes economic and governance institutions dataset of governance indicators of worldwide governance indicators (WGI) and economic freedom indicators of the Fraser Institute. Accordingly, the rule of law, absence of violence and instability, regulatory quality, government effectiveness, voice and accountability and control of corruption are used to capture the quality of governance institutions of African countries. The rule of law shows contract and property right protection and abilities of police and court to enhance private rights. Political stability and absence of violence represent the capacity of government in avoiding internal and external conflicts, and ethnic tensions and control of corruption indicates the position of countries in fighting against corruption. Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Voice and accountability catches view of the degree to which citizens can take an interest in selecting their government, opportunity of free expression and association, as well as a free media. Their values range approximately from –2.5 to 2.5 with higher values corresponding to better institutions.

Furthermore, economic freedom indicators are used to proxy for economic institutions of African countries. It has six components namely: property right and legal protection, regulation, sound money, freedom to trade internationally, government size and investment freedom. The interesting thing here is that all variables used to develop the index come from the international country risk guide, the global competitiveness report, and the World Bank’s doing business project so that the subjective judgments of the authors do not influence the index. Government size represents the extent of government consumption, tax rate, transfer and subsidy and government investment. Legal protection and property right shows the key ingredients of a legal system such as rule of law, security of property rights, an independent and unbiased judiciary, and impartial and effective enforcement of the law. Regulation represents labor and credit market and business regulation. In all cases, the values of these indicators vary from 0 to 10 with higher values corresponding to a better status.

Using indicators of institutional quality and economic freedom of African countries we derive a single composite indicator using principal component analysis. The results in Table 7 in Appendix B show that the eigenvalues of the first principal component of the quality of economic and governance institution is greater than 1 (4.61>1). However, none of the other components have eigenvalues more than 1. Since the first component explains 66% of the variation in the original variables, the study uses the eigenvectors of the first principal component as weights in constructing an institutional and governance index. Among the indicators rule of law, regulatory quality, government effectiveness and control of corruption have more contribution as they have a relatively larger magnitude of eigenvalues (see Table 7 in Appendix B.1).

Border and transport efficiency indicator

We add border and transport efficiency indicators into our analysis using four sets of transport and border efficiency indicators. These are time required to export, time required to import, documents required to export and documents required to import. The time required to export and import is measured by time recorded in calendar days. The time calculation for an export or import process starts from the moment it is started and runs until it is completed. All documents required per shipment to export or import goods are captured. This is based on the assumption that all contracts have already been agreed upon and signed by both parties. Documents needed for clearance by port and container terminal authorities, customs authorities, health and technical control agencies, banks and government ministries are taken into account. Similarly using principal component analysis, we find one aggregate indicator of border and transport efficiency index. From the results in Table 7 in Appendix B.1, the eigenvalues of the first two components of the border and transport efficiency are greater than 1 (2.62 and 1.03>1). The first principal component of border and transport efficiency has variance 2.62, explaining 66% of the total variance. Hence we include the first principal component of border and transport efficiency indicator to our specification. In this component time required to export and import is more important because the eigenvalues of time required to import and export have relatively larger values compared to documents required to import and export (see Table 7 in Appendix B.1). We hypothesize that there should be a negative relationship between border and transport efficiency indicators and trade flow as ease of cross-border trading activities promotes flow inflow.

Physical and communication infrastructure indicator

Physical and communication infrastructure shows the quality of airports, roads, railway infrastructure and level of communication infrastructure. We derive aggregate indicator for physical and communication infrastructure using road quality, railway quality, airports quality, internet subscription and telecommunication infrastructure. The eigenvalues of the first two components are greater than 1 (2.562 and 1.339>1). The first principal component has a variance of 2.562, explaining 51% of the total variance and the second one has a variance of 1.339, explaining 26.8%. The interaction of these components is used as it accounts for more than 77% (see Appendix B.1). The pair-wise correlation of individual indicators used to drive these indices is reported in in Appendix B.3.

Entry cost index

We control for entry cost index using three ease of doing business indicators such as cost to start business, procedure and time required to start the business in exporter countries using a similar procedure. In this index, the procedure to start business and time required to start business are more important because their contribution is relatively larger than the cost to start the business (see Appendix B.1).

3.2 Methods of analysis

This part is concerned with the description of the estimation method used in the study. We start by introducing an empirical gravity model that is used to investigate the effect of factors affecting bilateral trade patterns. Traditional gravity specification assumes that the gravitational force between two objects is positively dependent on the mass of the objects and negatively dependent on the physical distance between them (Isard, 1954). Trade flow between countries is a function of the mass of the country of origin, the mass of the country of destination and the physical distance between the two countries (Linders et al., 2008). It can be represented by (1):

$$Trade_{ij} = \chi M_i^{\beta_n} M_j^{\beta_m} \Big/ TB_{ij}^{\beta_z} \tag{1}$$

where, $Trade_{ij}$ is trade probability or trade volume of countries; M_i and $M_j$are the mass of the origin and destination countries, respectively; TB_{ij} is physical distance between origin and destination countries. β and χ represent parameters and constant, respectively. Equation (1) can be extended to include traditional gravity variables, institutional quality and infrastructure indicators.

Transforming the gravity model in (1) and using OLS estimator results in loss of information because of dropping zero value observations in the trade data. Our sample has 30% zero valued observations. Hence this procedure reduces the efficiency of data and may lead to biased estimates since dropping zero value observations in the estimation results with selection bias (Gómez-Herrera, 2013). Another method used by Baldwin and Di Nino (2006) to solve zero value observations in the data is the Tobit model to estimate the common currency effect on trade in new goods by applying the gravity model. However, this method is inefficient since it results with a loss of information and leads to biased results because of censuring zero trade values from the left.

Alternative methods commonly used in gravity model specification are (PPML) and Heckman selection models. PPML model by Santos Silva and Tenreyro (2006) is a preferred estimation method in the presence of heteroscedasticity. However, this method is not appropriate if the probability of trade among countries is correlated with unobserved characteristics of the pair of countries and severely biased when zeros are not random outcomes (Westerlund and Wilhelmsson, 2011). In addition, it does not behave so well for an aggregated dataset in the presence of unobserved heterogeneity. Furthermore, there are various extensions of the PPML estimator that can be used in gravity estimation. Among these extended versions of PPML, negative binomial pseudo-maximum likelihood (NBPML) is a more general version that

encompasses the broad family of pseudo-maximum likelihood. However, its binomial distribution relies on the assumption that the conditional variance is a linear combination of the conditional mean and its square. Furthermore, in many cases, it is inappropriate when dealing with continuous data and very scale-dependent and fail to recover the elasticities in the gravity equation (Bosquet and Boulhol, 2010; Xiong and Chen, 2014).

Another alternative model robust to handle zero valued observations is a hurdle Poisson negative binomial model that distinguishes whether or not trade between countries occurs and, given that two countries are trading, how large a volume of trade takes place. Hurdle type with negative binomial will also haveconvergence problems and the complexity will make this model unreliable (Cantoni and Zedini, 2011; Baetschmann and Winkelmann, 2016). Gómez-Herrera (2013) comparing different methods to estimate gravity models of bilateral trade for a dataset covering 80% of world trade showed that the best method to estimate a gravity model of bilateral trade is Heckman sample selection procedure. This study revealed that Heckman (1979) sample selection model is the estimator with the most desirable properties, confirming the existence of sample selection bias and the need to take into account the first step (probability of exporting) to avoid the inconsistent estimation of gravity parameters.

Therefore, in this study, we employ two-step Heckman (1979) sample selection procedure to estimate the gravity model of trade flow of African countries since there are zero value observations in our trade flow data. In addition, it allows for a two-stage decision process via estimating determinants of the probability to trade (extensive margin) simultaneously with estimating determinants of bilateral trade flow (intensive margin), avoiding any bias involved because of sample selection and omission of the extensive margin (Helpman et al., 2008). Conceptually, this model consists of two parts: Outcome or observed counterpart (intensive margin) and selection part (extensive margin).

Therefore, based on the gravity specification in (1) the intensive and extensive margins of our estimation are defined in (2) and (4) below.

$$\ln(Trade_{ijt}) = \beta_0 + \beta_n(OV_{ijt}) + \beta_m(IV_{it}) + \beta_k(MR_{ijt}) + \gamma_t + \varepsilon_{ijt} \quad (2)$$

where, $Trade_{ijt}$ denotes bilateral trade flow between *i* and *j* countries; OV_{ijt} represents other control variables such as GDP per capita of reporter, GDP per capita of partner, distance between capital of *i* and *j* countries, population density of*i* and *j* countries, colonial relationship, common colony, common language, common currency, WTO membership, areal size of reporter and partners countries, RTA and access to sea; IV_{it} represents border and transport efficiency, quality of economic institutions, physical and communication infrastructure of African countries and MR_{ijt} is inverse Mills ratio. γ_t andε_{ijt} show time fixed effect and stochastic term. All non-dummy variables are in natural logarithm form.

Multilateral resistance term (MRT), which is a function of exogenous variables, is taken in to account by employing the Baier and Bergstrand (2009) method.[1]Extensive margin (selection

[1]Using MRT captures the role of country size because trade barriers have a large impact for small countries which typically trade a large proportion of their output internationally (Portugal-Perez and Wilson, 2012). So, we replace bilateral variables that account for bilateral trade costs by MRT in the model using the following Baier and Bergstrand (2009) methods by indexing (i,b,c) for the reporter and (j,e,f) for partner countries.

equation) shows that $Trade_{ijt}$ defined in (2) is observed when the following conditions are satisfied.

$$TP^{*}_{ijt} = Y_{ijt}\varphi + v_{ijt}$$
$$TP_{ijt} = \begin{cases} 0, TP^{*}_{ijt} \leq 0 \\ 1, TP^{*}_{ijt} > 0 \end{cases} \quad (3)$$

where, TP_{ijt} is probability to trade, Y_{ijt}represents control variables including exclusion restriction variables and v_{ijt} represents stochastic term.

This equation captures zeros and explains why bilateral trade occurs at all. The size of trade in the (2) is, therefore, conditional on trade occurring among reporter and partner countries in (4) (Xiong and Chen, 2014).

$$TP^{*}_{ijt} = \varphi_0 + \varphi_n(OV_{ijt}) + \varphi_m(IV_{it}) + \varphi_k ECOST_{it} + \eta_t + U_{ijt} > 0 \quad (4)$$

where, $Trade_{ijt}$ denotes bilateral trade flow between *i*-reporter and *j*-partner countries; OV_{ijt} represents other control variables such as GDP of *i* countries, GDP of *j* countries, distance between capital of *i* and j countries, RTA_{ijt}, WTO membership, colonial relationship, common colony, common currency, common language, access to sea, population of both *i* and *j* countries and areal size of *i* and *j* countries; IV_{it} represents border and transport efficiency, physical and communication infrastructure and quality of institutions of African countries. $ECOST_{it}$denotesbusiness entry cost used as exclusion restriction. η_t and U_{ijt} are time fixed effect and stochastic term, respectively.

Therefore, improvement in trade facilitation fosters trade flow either through inducing more countries to participate in the world market or through enlarging the size of pre-existing trade or both. Business entry cost is represented by index derived using cost to start business, procedure and time to start business and used as an exclusion restriction. It is excluded from the outcome equation and included in selection equation as it can affect the probability of trade between partners and reporting countries (Helpman et al., 2008 and Araujo et al., 2012). The selection equation is used to calculate inverse Millis ratio which captures the probability of selection variables omitted from intensive margin (outcome equation) defined in (4).The selection equation is used to calculate inverse Millis ratio which captures the probability of selection variables omitted from intensive margin (outcome equation) defined in (2).

$$MRT \ln X_{ijt} = \ln X_{ijt} - \{\sum_{e \neq i} \theta_i \ln X_{eit} + \sum_{b \neq j} \theta_j \ln X_{bjt} - \sum_{c} \sum_{f} \theta_j \theta_i \ln X_{cft}\}$$

where, X is bilateral variables accounting for bilateral trade costs, $\theta_i = Y_i/Y_T$ and $\theta_j = Y_j/Y_T$, $Y_i = GDP_{it}$, $Y_T = GDP_{world}$

4 Results and findings

4.1 The impacts of border and transport efficiency, quality of institutions, physical and communication infrastructure on overall trade flow of African countries

Table 1 presents two-step Heckman (1979) estimation results for border and transport efficiency, quality of economic institutions, physical and communication infrastructure. Because of significant difference in observations and high correlation among each indicator of institutional quality and infrastructure indicators, we have considered them separately (see Table 8 in Appendix B.2 and Table 9 in Appendix B.3). However, we account for them simultaneously and the signs of their coefficients are in line with literature and robustly significant (see Table 10 in Appendix B.2). Border and transport efficiency, quality of institutions, physical and communication infrastructure indices are rescaled and their values range in between 0 and 1. Therefore, the coefficients of these indicators are comparable.

Market entry cost is considered as exclusion restriction variable and included in extensive margin defining the probability of trade among countries. It has negative effect on the probability of countries to participate in trade. Countries with high market entry cost have less probability to trade. Its coefficient is significant at 1% level of significance in all specifications. The results are vigorous because to find stable and robust results, exclusion restriction variables should have the coefficients that accord with intuition and statistically significant at conventional levels. The Mills ratio is statistically significant at 1% level of significance implying that there is an existence of sample selection bias and strongly supports using two-step Heckman (1979) sample selection procedure.

The estimated coefficients of all standard trade flow variables are significant and their signs are consistent with the predictions of the gravity model for both outcome and selection equations except for the colonial relationship between reporter and partner countries as its effect on extensive margin is significant and negative. The economic size represented by GDP per capita of the African countries and their trade partner countries significantly determine the trade flow of African countries and their probability to trade. Their effect is positive and significant at 1% level of significance. The geographical distance between African countries and their trade partners has a significant negative effect on both intensive and extensive margins indicating that physical distance discourages volume of trade and probability to trade. This result is consistent with the theory that the shorter the distance, the lower the transaction costs and the more the trade among countries. The population density of African countries and their trade partners have significantly positive effect on the trade flow of African countries. They have a robust effect on both intensive and extensive margins.

Furthermore, WTO membership for African countries has a significant positive effect on trade flow and the likelihood of trade in all specifications. This result is congruent with the view that WTO accurately promotes trade flow and enhances trade integration among member countries. The coefficient of common language is statistically significant and positive indicating that countries with common language have more trade flow compared to countries withdifferent languages. The coefficients of the common colony are robust positive showing that

Table 1: The impacts of border and transport efficiency, quality of institutions, physical and communication infrastructure on trade flow of African countries (twostep Heckman)

Variables	I (a) Outcome	I (b) Selection	II(a) Outcome	II(b) Selection	III(a) Outcome	III(b) Selection
$lngdpc_{it}$	1.258***	0.206***	1.221***	0.195***	1.235***	0.204***
	(0.026)	(0.006)	(0.029)	(0.006)	(0.038)	(0.007)
$lngdpc_{jt}$	0.978***	0.241***	1.025***	0.239***	0.953***	0.216***
	(0.021)	(0.004)	(0.026)	(0.004)	(0.031)	(0.005)
$lnpop_{it}$	1.860***	0.334***	1.840***	0.308***	2.079***	0.373***
	(0.033)	(0.006)	(0.037)	(0.006)	(0.055)	(0.008)
$lnpop_{jt}$	1.473***	0.267***	1.539***	0.263***	1.449***	0.240***
	(0.026)	(0.005)	(0.031)	(0.005)	(0.037)	(0.006)
$lndis_{ij}$	-0.614***	-0.019**	-0.597***	-0.013	-0.604***	-0.022**
	(0.028)	(0.008)	(0.033)	(0.008)	(0.042)	(0.011)
$comrelig_{ij}$	1.035*	0.193	0.692	0.031	0.985	0.271
	(0.600)	(0.193)	(0.689)	(0.190)	(0.899)	(0.250)
$comcol_{ij}$	0.590***	0.095***	0.413***	0.033*	0.203**	-0.026
	(0.061)	(0.018)	(0.068)	(0.017)	(0.089)	(0.023)
$colrel_{ij}$	0.578***	-0.601***	0.546**	-0.548***	0.135	-0.650***
	(0.204)	(0.077)	(0.231)	(0.076)	(0.299)	(0.096)
WTO_i	1.248***	0.426***	1.383***	0.424***	1.588***	0.453***
	(0.063)	(0.014)	(0.075)	(0.014)	(0.100)	(0.018)
WTO_i	0.421***	0.047**	0.497***	0.076***	-0.009	-0.013
	(0.063)	(0.019)	(0.056)	(0.014)	(0.085)	(0.022)
$lnarea_j$	-0.177***	-0.003	-0.213***	-0.007**	-0.198***	0.002
	(0.012)	(0.003)	(0.014)	(0.003)	(0.017)	(0.005)
$lnarea_i$	-0.343***	-0.058***	-0.258***	-0.041***	-0.535***	-0.107***
	(0.017)	(0.005)	(0.019)	(0.005)	(0.028)	(0.006)
$lnentrycost_{it}$		-0.296***		-0.276***		-0.279***
		(0.021)		(0.020)		(0.024)
lan_{ij}	1.558***	0.375***	1.779***	0.403***	1.918***	0.438***
	(0.056)	(0.016)	(0.067)	(0.016)	(0.090)	(0.021)
Sea_i	1.448***	0.278***	1.404***	0.236***	0.775***	0.064***
	(0.049)	(0.013)	(0.056)	(0.013)	(0.068)	(0.018)
RTA_{ij}	3.216***	0.681***	3.285***	0.691***	3.022***	0.640***
	(0.071)	(0.025)	(0.086)	(0.025)	(0.105)	(0.031)
$cocur_{ij}$	2.858***	0.492***	3.077***	0.485***	2.621***	0.400***
	(0.127)	(0.040)	(0.151)	(0.042)	(0.188)	(0.051)
$ln(eco\_institutionst_i)$	0.110***	-0.009				
	(0.029)	(0.009)				
$ln(border\_transport_{it})$			-0.149***	-0.033***		
			(0.016)	(0.004)		
$ln(physical\_ communication_{it})$					0.475***	0.082***
					(0.036)	(0.009)
_cons	-9.981***	-3.553***	-14.251***	-4.387***	-6.044***	-2.510***
	(0.498)	(0.090)	(1.293)	(0.270)	(0.697)	(0.122)
Mills ratio	4.136***		4.616***		4.523***	
	(0.158)		(0.188)		(0.243)	
No. obs.	71,175		70,255		41,471	
Censored obs.	27,657		29,602		17,440	
Wald $\chi 2$	6894.65		5025.26		3067.29	

Notes: i=1,…, 44 and j=1,…,173 indicate the reporter and partner country, respectively. All specifications include time fixed effects and MRT corrections for bilateral trade cost variables. Standard errors are reported in parenthesis. ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

countries which have common colony trade more and participate in trade integration compared to countries which have no common colony. Similarly, the coefficient of colonial relationship has a positive effect on intensive margin implying that colonial relationship significantly affects the volume of trade. However, it has negative effect on extensive margin. The impact of common currency is robust and indicates countries which have common currency trade more compared to countries which use different currencies.

The other important traditional gravity variables significantly affecting the trade flow of African countries are access to sea and regional trade agreements. The coefficients of both access to sea and regional trade agreements are positive showing that countries which have access to sea and are members of regional trading blocs trade more and will have a higher probability to trade compared to countries which have no access to sea and are not the members of regional trading blocs. In addition, we repeat this exercise controlling for tariff imposed on trade by trade partner countries. However, because of a significant reduction in the sample size we have conducted the model separately and reported the result in Table 13 in Appendix C.

Turning to our explanatory variables of main interest, the border and transport efficiency indicator has a highly significant negative effect on the trade flow of African countries. It also has a robust effect on probability to trade. Its impact is significant at 1% level of significance indicating that improving border and transport efficiency will have significantly positive influence on trade volume and probability of trade for African countries. This result is reasonable because according to the world development indicator of World Bank database, most countries that require the highest number of documents to import and export and a relatively long time to trade are located in Africa. This finding is consistent with the results of Seck (2017) that suggest reduction in time and documents to trade have a substantial effect on the trade flow of Sub-Saharan African countries.

The impact of physical and communication infrastructure of African countries on trade flow is robust positive. This result is steady with the view that the better the communication infrastructure, the more accessible information about the foreign market. Acquiring important information in turn benefits traders by decreasing the costs of trade. Therefore, increasing telephone and mobile subscriptions reduces transport and transit costs of trade and boosts trade performance of African countries. Likewise, improving the quality of physical infrastructure enhances the trade flow of African countries. Hence, improvement in a country's quality of physical and communication infrastructure can make a significant difference to the trade performance of African countries. These results are in line with the findings of Seck (2017), Francois and Manchin (2013) and Portugal-Perez and Wilson (2012) that determines improvement in physical and communication infrastructure enhances trade performance of developing countries including Sub-Saharan African countries.

Similarly, the effect of quality of institutions on volume of trade is robust positive. It implies that improving the quality of economic and governance institutions enhances trade flow and positively contributes to the probability of countries to trade. This result tends to be consistent with the study by Francois and Manchin (2013) that concludes trade fellow of developing countries robustly depends on institutional quality.

We have repeated the exercise using border and transport efficiency, physical and communication infrastructure indicators separately. The results are reported in Table 11a and Table 11b in Appendix C. The results using the variables measuring different aspects of the

border and transport efficiency (time document to export and import) have a robust negative impact on trade flow and the likelihood of African countries to trade. The coefficients of all physical and communication infrastructure indicators are positive and significant at 1% level of significance indicating an improvement of each indicator of infrastructure has a robust effect on enhancing trade flow of African countries (see Table 11a and Table 11b in Appendix C).

In addition, we estimate an interaction term for the quality of institutions, border, and transport efficiency and physical and communication infrastructure with respect to GDP per-capita of African countries. All interaction terms are statistically significant. The marginal effect of the quality of economic institutions, physical and communication infrastructure on trade flow seems to be increasing in GDP per capita. In contrast, the marginal effect of border and transport efficiency on trade decreases in GDP per capita (see Table 10 in Appendix C). Hence improvement in the quality of institutions and physical and communication infrastructure highly important for relatively richer African countries whereas improvement in border and transport efficiency is increasingly important to African countries with relatively lower GDP per capita income to enhance trade volume.

4.2 The impacts of border and transport efficiency, quality of institutions, physical and communication infrastructure on intra-Africa trade

Africa's trade is more dominated by extra-Africa trade. However, intra-Africa trade shares less than 12% of Africa's total trade which is extremely low compared to intra-regional trade in other parts of the world. We run separate estimation constraining trade flow to intra-Africa. As the coefficient of entry cost is robust negative, countries with high market entry cost have less probability to trade. This result is important because to find stable and robust results, exclusion restriction variables should have the coefficients that are statistically significant at conventional levels. The Mills ratio is also statistically significant implying that there is an existence of sample selection bias and strongly supports our exercise.

Our results in Table 2 disclose that the coefficients of all standard trade flow variables are significant and their signs are consistent with the predictions of the gravity model for both outcome and selection equations. In addition, the coefficient of common religion is changed to positive and significant.

The coefficient of border and transport efficiency variable is negative and significant at 1% level of significance. Quality of institutions has also a robust positive effect on the volume of trade and probability to trade. Furthermore, improvement in physical and communication infrastructure enhances intra-Africa. However, its impact on extensive margin is insignificant. However, the magnitude of the coefficient of border and transport efficiency is the biggest compared to the quality of institutions, physical and communication infrastructure implying that improving border and transport efficiency contributes more to intra-regional trade flow than from improvement in physical and communication infrastructure and domestic institutions. Therefore, to advance intra-Africa trade improving infrastructure and institutional quality is worthwhile. Furthermore, it needs improvement in border and transport efficiency to facilitate intra-Africa trade. These results are tend to be aligned with the results of Geda and Seid (2015)

that conclude any effort to advance regional integration through intra-Africa trade is challenged by weak infrastructure, productivity and trade facilitation.

5 Robustness check and counterfactual estimation

5.1 Robustness check

According to some literature, there will be reverse causality between infrastructure and trade. The same problem will happen between institutional quality and trade. That is the efficiency of infrastructure and institutional quality will be driven by trade integration and trade integration can also be driven by good institutions and quality of infrastructure. However, the infrastructure and quality of institutions will have a more direct and immediate effect on the likelihood of trade and volume of trade. On the other hand, the impact of trade on improvement of institutional quality and infrastructure is less direct and sluggish to be recognized (Portugal-Perez and Wilson, 2012). Though the existence of reverse causality is less, examining the possibility that our results are driven by reverse causality is worthwhile. To address this problem we did three things. First, we aggregate infrastructure indicators by principal component analysis that partly reduces the endogeneity problem. Second, we run a model constraining to only intra-Africa trade that we spell out in Table 2. Excluding these countries will limit the trade flow of African countries to only 12% of our sample. When extra-Africa trade partners are excluded, the correlation between infrastructure and trade should become weaker if there is reverse causality (Julian et al., 2015). The underlying assumption is that Africa's trade with its major trade partners is relatively important to drive the demand for better infrastructure and, thus, provide relevant incentives to improve the countries' endowment with infrastructure and institutional quality. Our results in Table 2 prove to be robust to the exclusion of extra-Africa major trade partners or controlling only to intra-Africa trade. Almost all control variables are hardly affected when we exclude these countries suggesting our findings are unlikely to suffer from serious reverse causality problems.

Finally, we conduct IV estimator to control for endogeneity. Physical and communication infrastructure, border and transport efficiency indicators are instrumented by civil liberty, government fractionalization, and checks and balance, respectively following works of Julian et al. (2015) and Lin (2015) who used these variables as an instrument for infrastructure and internet. Furthermore lagged values of time-varying explanatory variables are used as instruments. We add legal origin as an instrument for the indicator of institutional quality (Borrmann et al., 2006). In our analysis, we consider countries with French legal origin have lower institutional quality and highly regulated business environment because the French legal origin is highly correlated with an excessive regulatory environment and may lead to lower quality institutions, particularly when the French legal system was implemented in developing countries (Djankov et al., 2002). However, common law (English origin) provides the next highest quality of law enforcement and also the highest protection (La Porta et al., 1998). Table 3 and Table 4 provide IV results for overall and intra-Africa trade. These results provide evidence that our baseline estimation results are robust.

Table 2: The impacts of border and transport efficiency, quality of economic institutions, physical and communication infrastructure on intra-Africa trade

Variables	I (a) Outcome	I(b) Selection	II (a) Outcome	II (b) Selection	III(a) Outcome	III(b) Selection
$lngdpc_{it}$	1.075***	0.251***	1.012***	0.151***	1.162***	0.241***
	(0.047)	(0.014)	(0.048)	(0.014)	(0.074)	(0.016)
$lngdpc_{jt}$	0.882***	0.303***	1.006***	0.299***	1.045***	0.273***
	(0.051)	(0.014)	(0.061)	(0.013)	(0.081)	(0.016)
$lnpop_{it}$	1.729***	0.471***	1.832***	0.408***	1.991***	0.474***
	(0.070)	(0.014)	(0.075)	(0.014)	(0.125)	(0.018)
$lnpop_{jt}$	0.934***	0.325***	1.159***	0.333***	1.112***	0.312***
	(0.057)	(0.016)	(0.070)	(0.015)	(0.094)	(0.019)
$lndis_{ij}$	-0.479***	0.082***	-0.479***	0.051**	-0.328***	0.086***
	(0.053)	(0.020)	(0.060)	(0.020)	(0.079)	(0.024)
$comrelig_{ij}$	5.064***	0.648	3.530***	-0.506	3.877**	-0.456
	(0.972)	(0.448)	(1.145)	(0.401)	(1.531)	(0.520)
$comcol_{ij}$	0.903***	0.533***	0.749***	0.334***	0.793***	0.330***
	(0.114)	(0.036)	(0.115)	(0.033)	(0.161)	(0.045)
WTO_i	1.200***	0.242***	1.210***	0.215***	1.381***	0.262***
	(0.092)	(0.030)	(0.103)	(0.029)	(0.144)	(0.037)
WTO_i	1.184***	0.128***	1.250***	0.228***	0.736***	0.034
	(0.109)	(0.041)	(0.106)	(0.030)	(0.155)	(0.046)
$lnarea_j$	-0.147***	-0.077***	-0.207***	-0.070***	-0.199***	-0.065***
	(0.030)	(0.011)	(0.035)	(0.011)	(0.046)	(0.014)
$lnarea_i$	-0.374***	-0.148***	-0.272***	-0.061***	-0.506***	-0.167***
	(0.034)	(0.010)	(0.036)	(0.011)	(0.058)	(0.014)
$lnentrycost_{it}$		-0.364***		-0.288***		-0.286***
		(0.076)		(0.074)		(0.096)
lan_{ij}	0.690***	0.045	0.898***	0.156***	1.002***	0.191***
	(0.086)	(0.033)	(0.099)	(0.030)	(0.141)	(0.043)
Sea_i	1.414***	0.326***	1.187***	0.162***	1.246***	0.167***
	(0.087)	(0.027)	(0.097)	(0.030)	(0.122)	(0.036)
RTA_{ij}	2.909***	0.461***	3.022***	0.517***	2.904***	0.461***
	(0.090)	(0.031)	(0.114)	(0.031)	(0.147)	(0.038)
$cocur_{ij}$	1.230***	0.226***	1.773***	0.305***	1.246***	0.231***
	(0.117)	(0.048)	(0.147)	(0.048)	(0.188)	(0.059)
$ln(eco\_institutions_{it})$	0.454***	0.046**				
	(0.049)	(0.018)				
$ln(border\_transport_{it})$			-0.977***	-0.391***		
			(0.096)	(0.026)		
$ln(physical\_communicati_{it})$					0.170**	-0.027
					(0.067)	(0.021)
_cons	-4.942***	-2.137***	-11.867***	-3.366***	-6.488***	-2.032***
	(0.823)	(0250)	(3.483)	(0.981)	(1.293)	(0.295)
Mills ratio	2.631***		3.852***		3.700***	
	(0.309)		(0.352)		(0.507)	
No. obs.	16,022		16,193		9,674	
Censored obs.	5,006		5,848		3,446	
Wald $\chi 2$	2245.3		1508.5		900.22	

Notes: i=1,…, 44 and j=1,…,44 indicate the reporter and partner country, respectively. All specifications include time fixed effects and MRT corrections for bilateral trade cost variables. Standard errors are reported in parenthesis. ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

Furthermore, we check the consistency of the results reported in Table 1 using the PPML. In PPML, the dependent variable (trade flow) is introduced in levels instead of logarithms. The results are displayed in Table 12 in Appendix C. The findings show that the coefficients of two indicators of infrastructure and institutional quality variables have expected signs and are significant at a substantial level. However, the sign of transport and border efficiency indicator is changed to negative and statistically significant. We also find sign reversal for some

traditional gravity variables such as population density of African countries, areal size of destination countries and common religion ($lnpop_{it}$, $lnarea_i$ and $comrelig_{ij}$) that may be because of convergence problems of PPML estimator in Stata. Furthermore, the coefficients of some variables turned to be statistically insignificant.

Table 3: The effects of quality of economic institutions, border and transport efficiency, and physical and communication infrastructure on overall trade flow (IV regression results)

Variables	I	II	III
$lngdpc_{it}$	0.679***	0.013	0.661***
	(0.020)	(0.397)	(0.064)
$lngdpc_{jt}$	0.486***	0.607***	0.629***
	(0.010)	(0.016)	(0.017)
$lnpop_{it}$	1.162***	1.036***	1.533***
	(0.022)	(0.142)	(0.050)
$lnpop_{jt}$	0.772***	1.220***	1.256***
	(0.013)	(0.017)	(0.020)
$lndis_{ij}$	-0.641***	-0.764***	-0.605***
	(0.023)	(0.088)	(0.037)
$comrelig_{ij}$	-0.287	0.698	-1.127
	(0.462)	(0.576)	(0.781)
$comcol_{ij}$	0.278***	0.188*	0.276***
	(0.049)	(0.108)	(0.094)
$colrel_{ij}$	0.459***	-0.007	0.015
	(0.044)	(0.062)	(0.073)
WTO_i	0.435***	0.664***	0.349***
	(0.053)	(0.095)	(0.093)
WTO_i	-0.050***	-0.269***	-0.285***
	(0.009)	(0.013)	(0.014)
$lnarea_j$	-0.157***	0.526	-0.414***
	(0.014)	(0.349)	(0.053)
$lnarea_i$	2.275***	1.488***	1.421***
	(0.117)	(0.142)	(0.150)
lan_{ij}	0.866***	1.021***	1.166***
	(0.041)	(0.061)	(0.063)
Sea_i	0.899***	0.957***	0.579***
	(0.059)	(0.100)	(0.160)
RTA_{ij}	2.387***	2.728***	2.609***
	(0.044)	(0.061)	(0.069)
$cocur_{ij}$	1.447***	2.486***	1.879***
	(0.084)	(0.242)	(0.137)
$ln(eco\_institutions_{it})$	0.679***		
	(0.194)		
$ln(border\_transport_{it})$		-1.314**	
		(0.670)	
$ln(physical\_communication_{it})$			0.847***
			(0.261)
Cons	0.779*	-4.656**	6.062***
	(0.416)	(2.011)	(1.838)
Obs.	50072	32108	18908
R2	0.347	0.316	0.4458
Wald $\chi 2$	0.000	0.000	0.000
F-statistic	1157.17	45.13	372.99
Robust score $\chi 2$	0.007	0.056	0.0046

Notes: i=1,…, 44 and j=1,…,173 indicate the reporter and partner country, respectively. All specifications include time fixed effects. Standard errors are reported in parenthesis. Wald, F-statistic, Robust score $\chi 2$indicate overall model fit, the strength of instruments and endogeneity test results, respectively. ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

Table 4: The effects of quality of economic institutions, border and transport efficiency, and physical and communication infrastructure on intra-Africa trade (IV regression)

Variables	I (a) Outcome	II (a) Outcome	III(a) Outcome
$lngdpc_{it}$	0.611*** (0.034)	0.197* (0.108)	0.591*** (0.046)
$lngdpc_{jt}$	0.288*** (0.024)	0.453*** (0.032)	0.487*** (0.040)
$lnpop_{it}$	1.135*** (0.045)	0.960*** (0.046)	1.127*** (0.047)
$lnpop_{jt}$	0.333*** (0.028)	0.553*** (0.038)	0.502*** (0.051)
$lndis_{ij}$	-0.668*** (0.044)	-0.645*** (0.052)	-0.540*** (0.066)
$comrelig_{ij}$	5.590*** (0.903)	3.080*** (1.149)	5.837*** (1.305)
$comcol_{ij}$	0.076 (0.074)	-0.018 (0.097)	0.047 (0.117)
WTO_i	0.864*** (0.069)	0.740*** (0.087)	0.811*** (0.109)
WTO_i	1.174*** (0.108)	0.709*** (0.099)	0.996*** (0.126)
$lnarea_j$	0.090*** (0.021)	-0.038 (0.030)	-0.041 (0.038)
$lnarea_i$	-0.142*** (0.142)	0.234*** (0.083)	-0.210*** (0.037)
lan_{ij}	0.907*** (0.077)	0.722*** (0.090)	0.939*** (0.114)
Sea_i	1.171*** (0.083)	0.306** (0.151)	0.914*** (0.113)
RTA_{ij}	2.495*** (0.065)	2.312*** (0.073)	2.332*** (0.097)
$cocur_{ij}$	0.701*** (0.106)	1.418*** (0.133)	0.576*** (0.153)
$ln(eco\_institutions_{it})$	1.485** (0.604)		
$ln(border\_transport_{it})$		-2.136*** (0.350)	
$ln(physical\_\ communicati_{it})$			2.219*** (0.592)
Cons.	0.616 (0.658)	-2.765*** (0.815)	2.204** (0.851)
Ob.	13217	10297	6405
R2	0.3503	0.2688	0.305
Wald $\chi 2$	7049.6	4249.3	2940.63
F-statistic	186.078	418.828	386.433
Robust score $\chi 2$	0.4406	0.000	0.000

Notes: i=1,…, 44 and j=1,…, 44 indicate the reporter and partner country, respectively. All specifications include time fixed effects. Standard errors are reported in parenthesis. Wald, F-statistic, Robust score $\chi 2$ indicate overall model fit, strength of instruments and endogeneity test results, respectively. ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

5.2 Counterfactual analysis

Based on our estimates in Table 1 we simulate the effects of border and transport efficiency, the quality of economic institutions and physical and communication infrastructure on trade flow to the best-performing country in the sample. This simulation indicates the percent of the average African economy would gain by improving these indicators to the best performer (Table 5). To

show how these counterfactuals are estimated, for example, suppose that a reform on border and transport efficiency of African countries leads to a 1% increase in the in border and transport efficiency index. This, in turn, results in $\widehat{\beta}_{border\_transport}$ percent improvement in trade performance. The percentage change in trade flows made by improvement in border and transport efficiency of African countries to the best-performing country can be converted to distance equivalent value using $\hat{\beta}_{border\_transport} / \hat{\beta}_{distance}$. For instance, if a reform is made to improve the transport efficiency of average African economies to Mauritius (the best-performing country in border and transport efficiency), trade flow would be improved by 8.32%. This improvement in trade would be equivalent to a reduction of 13.94% or 986.98 km in distance. Similarly, improvement in the institutional quality of average African economies to Botswana (the best-performing country in quality of institutions), trade flow would be enhanced by 9.41% that is equivalent to a reduction of 15.33% and 1085.39 km in distance. The effect of physical and communication infrastructure is relatively the highest compared to the impact of quality of institutions and border and transport efficiency. A reform that results in the improvement of physical and communication infrastructure of African countries to South Africa, the trade would improve by 9.83%. This figure translates to a distance equivalence of 16.27% and 1151.95 km reduction. The results of distance equivalence imply that the gain from improvement in physical and communication infrastructure more robust for overall trade performance of African countries.

Table 5: Simulation results

Policy variables	Trade flow (%)	Distance reduction (%)	Distance equivalence (km)
Border_transport	8.32	13.94	986.98
Physical_ communication	9.83	16.27	1151.95
Quality of eco_institutions	9.41	15.33	1085.39

6 Conclusions and policy implications

In this paper, we examine the impact of quality of institutions, border and transport efficiency, physical and communication infrastructure indicators on overall and intra-Africa trade for a dataset covering a wide range of Africa's trade partners. Our study covers 44 African countries as reporter and 173 trade partner countries. We use two-step Heckman (1979) sample selection procedure that allows for a two-stage decision process through estimating extensive and intensive margins simultaneously avoiding any bias involved because of sample selection and omission of the extensive margin. We also examine the impact of institutional quality and infrastructure restricting sample of trade flow to intra-Africa trade. In addition, we conduct robustness check for endogeneity using IV estimator. IV method is applied using check and balance, government fractionalization, Civil liberty and legal origin and lagged values of time-varying independent variables as instruments for physical and communication infrastructure,

border and transport efficiency and institutional quality indicators and the level values. Furthermore, we check the consistency of our estimates using the pseudo-maximum-likelihood (PPML) estimator. These tests disclose that our results are proven to be robust.

Controlling for different traditional gravity variables, we find that infrastructure, border efficiency and institutional quality variables are significant determinants not only of trade flow, but also of the probability of African countries to trade. Quality of physical and communication infrastructure has a robust positive effect on trade flow and the probability of African countries to trade. Hence improvement in efficiency of physical and communication infrastructure boosts trade performance of African countries. The results further indicate that both intensive and extensive margins are significantly affected by cross-border trade procedures and transport efficiency of African countries. These results are also supported by the results of disaggregated indicators of border and transport efficiency and infrastructure indicators. Our results also disclose that improvement in the quality of institutions is an important determinant of trade performance of African countries.

In addition, the marginal effect of the quality of institutions, physical and communication infrastructure on trade flow seems to be increasing in GDP per capita and the marginal effect of border and transport efficiency on trade volume decreases in GDP per capita. Our counterfactual analysis shows that improvements in the quality of institutions, border and transport efficiency, physical and communication infrastructure to the best-performing country in the sample can have a considerable effect on the trade flow of African economies.

To conclude, our results disclose that improvement in the efficiency of physical and communication infrastructure, border and transport efficiency and quality of institutions do not just influence the volume of trade for African countries, but also the probability that countries participate in trade. We can draw the following policy conclusion from our findings. To increase the volume of trade and integrate African countries with the rest of world and to facilitate intra-Africa trade, it is significantly important to improve quality of domestic institutions of African countries, physical and communication infrastructure, border and transport efficiency together because relying on investment of physical infrastructure without equally emphasizing on border and transport efficiency and institutional quality may not help reduce cost of trade in African countries and may not facilitate their trade performance.

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AppendixA: Data description

A.1 Source and definition of variables

Table 6: Source and definition of some important variables

Variables	Source	Unit of measurement
$Flow_{iit}$	DOTS	Trade flow (dependent variable
Traditional gravity variables		
$gdpca_i$	WDI	Per capita GDP of African countries
pop_i	CEPII	Total population of African countries in million
gdp_{ct}	WDI	Per capita GDP of trade partners
dis_{ict}	CEPII	Distance between capitals of African countries and trade partners
pop_{it}	CEPII	Total population of Trade partner countries' in million
$Comcol_{it}$	CEPII	Common colony
Col_{ij}	CEPII	Colonial relationship
Lan_{ij}	CEPII	Common language
$cocur_{ij}$	CEPII	Common currency
$Comrelig_{ij}$	CEPII	Common religion
$Tariff_{iit}$	WITS	Simple average
RTA_i	CEPII	Regional trade agreement
$Area_i$	CEPII	Areal size of African countries
$Area_j$	CEPII	Areal size of trade partner countries
Quality of economic institutions indicators		
cc_{it}	WGI	Control of corruption
rl_{it}	WGI	Rule of law
$stab_{it}$	WGI	Absence of violence and instability
va_{it}	WGI	Voice and accountability
rq_{it}	WGI	Regulatory quality
ge_{it}	WGI	Government effectiveness
$Soundmoney_{it}$	Fraser Institute	Sound money
$Regulation_{it}$	Fraser Institute	Business, credit and labor market regulation
$Intfree_{it}$	Heritage Foundation	Trade internationally freedom index
$Propertyright_{it}$	Fraser Institute	Property right
$Legelaenfo_{it}$	Fraser Institute	Legal enforcement
$Government_{it}$	Fraser Institute	Size of government in the economy
Entry cost indicators		
$Costs_{it}$	World Bank	Cost to start business
$Proc_{it}$	World Bank	Procedure to start business
$Time_{it}$	World Bank	Time to start business
Border and transport efficiency indicators		
$Docim_{it}$	WDI	Document to import
$Docex_{it}$	WDI	Document to export
$Timport_{it}$	WDI	Time to import
$Texport_{it}$	WDI	Time to export
Physical and ICT infrastructure indicators		
$Internet\_subscription_{it}$	WDI	Internet users (per 100 people) for the reporter
$Railway\_quality_{it}$	QOG	Quality of railway infrastructure
$Air\_quality_{it}$	QOG	Quality of airways
$Road\ \_quality_{it}$	QOG	Quality of road
$Telecommunication_{it}$	WDI	Fixed telephone subscriptions (per 100 people)

A.2 List of countries

African countries: Angola, Benin, Botswana, Burkina Faso, Cameroon, Congo Republic, Comoros, Cabo Verde, Cote d'Ivoire, Djibouti, Algeria, Egypt, Ethiopia, Gabon, Ghana, Gambia, The, Guinea Bissau, Guinea, Kenya, Liberia, Libya, Morocco, Madagascar, Mali, Mozambique, Mauritius, Malawi, Mauritania, Namibia, Niger, Nigeria, Rwanda, Sudan, Senegal, Sierra Leone, Seychelles, Chad, Togo, Tunisia, Tanzania, Uganda, South Africa, Zambia and Zimbabwe.
Trade partner countries: Aruba, Afghanistan, Albania, United Arab Emirates, Argentina, Armenia, Australia, Austria, Azerbaijan, Belgium, Benin, Burkina Faso, Bangladesh, Bulgaria, Bahrain, Bahamas, Bosnia and Herzegovina, Belarus, Belize, Bermuda, Bolivia, Brazil, Barbados, BruneiDarussalam, Canada, Switzerland, Chile, China, Cote d'Ivoire, Cameroon, Congo Republic, Colombia, Comoros, Capo Verde, Costa Rica, Cuba, Cyprus, Czech Republic, Germany, Djibouti, Dominica, Denmark, Dominican Republic, Algeria, Ecuador, Egypt, Spain, Estonia, Ethiopia, Finland, Fiji, France, Faeroe Islands, Gabon, United Kingdom, Georgia, Ghana, Guinea, Gambia, Guinea Bissau, Equatorial Guinea, Greece, Grenada, Greenland, Guatemala, Guyana, Hong Kong, Honduras, Croatia, Haiti, Hungary, Indonesia, India, Ireland, Iran, Iraq, Iceland, Israel, Italy, Jamaica, Jordan, Japan, Kazakhstan, Kenya, Kyrgyz Republic, Cambodia, St. Kitts and Nevis, Korea Republic, Kuwait, Lao PDR, Lebanon, Liberia, Libya, St. Lucia, Sri Lanka, Lithuania, Latvia, Maccau (China), Morocco, Moldova, Madagascar, Maldives, Mexico, Macedonia, Mali, Malta, Myanmar, Mongolia, Mozambique, Mauritania, Mauritius, Malawi, Malaysia, New Caledonia, Niger, Nigeria, Nicaragua, Netherlands, Norway, Nepal, New Zealand, Oman, Pakistan, Panama, Peru, Philippines, Papua New Guinea, Poland, Korea Democratic Republic, Portugal, Paraguay, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Sudan, Senegal, Singapore, Solomon Islands, Sierra Leone, El Salvador, Sao Tome and Principe, Suriname, Slovak Republic, Slovenia, Sweden, Seychelles, Syrian Arab Republic, Chad, Togo, Thailand, Tajikistan, Turkmenistan, Tonga, Trinidad and Tobago, Tunisia, Turkey, Tanzania, Uganda, Ukraine, Uruguay, United States, Uzbekistan, St. Vincent and the Grenadines, Venezuela, Vietnam, Vanuatu, Samoa, Yemen, South Africa, Zambia and Zimbabwe.

Appendix B: Principal Component analysis, summary statistics of major variables and correlations

B.1 Principal Component analysis (PCA)

We prefer this method because it allows us to apply a purely mathematical transformation without taking into account any priors about the underlying data structure. We have derived four aggregate indicators (entry cost, quality of economic institutions, border and transport efficiency and physical and communication infrastructure) from 24 single variables using principal component analysis that aim to reduce the dimensionality in data. It changes the data into new aggregate variables. To derive these indicators we used variables mentioned in Table 6 in

Appendix A. The information available in a group of variables is summed up by a number of mutually independent principal components. Each principal component is essentially the weighted average of the variables included. The eigenvalues and the components are given in Table 7 below. The eigenvalues are the variances of the principal components. The first principal component usually has the maximum variance for any of the combination. Similarly, in all cases the Kaiser-Meyer-Olkin Measure (KMO) of sampling adequacy is used to check for the appropriateness of the PCA, this is greater than the minimum KMO criteria of 0.50 for PCA analysis.

Table 7: Results of the principal component analysis

Political and governance index

Component	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC7
Eigenvalue	4.610	0.872	0.664	0.505	0.172	0.091	0.087
Proportion	0.659	0.125	0.095	0.072	0.025	0.013	0.013
Cumulative	0.659	0.783	0.878	0.950	0.975	0.988	1.000

Eigenvectors

Variables	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5	Vector 6	Vector7	KMO
Voice_accountability	0.274	-0.593	0.709	0.124	0.178	0.151	-0.040	0.768
Rule of law	0.444	0.020	-0.174	-0.066	-0.075	-0.002	-0.873	0.860
corruptioncontrol	0.420	-0.018	-0.295	-0.155	0.792	-0.195	0.216	0.917
Gov.effectiveness	0.424	-0.041	-0.174	-0.420	-0.294	0.659	0.305	0.837
Regu.qualirty	0.433	0.054	0.189	-0.237	-0.439	-0.683	0.242	0.807
Stability	0.350	-0.122	-0.328	0.824	-0.195	0.030	0.194	0.874
economicfreedom	0.249	0.793	0.456	0.213	0.137	0.194	0.026	0.693
Overall KMO								0.838

ICT and physical infrastructure quality

Component	PC1	PC2	PC3	PC4	PC4
Eigenvalue	2.562	1.339	0.699	0.322	0.078
Variance Proportion	0.512	0.268	0.140	0.064	0.016
Cumulative Proportion	0.512	0.780	0.920	0.984	1.000

Eigenvectors

Variables	Vector 1	Vector 2	Vector 3	Vector4	Vector5	KMO
Internet subscription	0.106	0.702	-0.637	0.289	0.080	0.366
Railway quality	0.599	0.020	-0.108	-0.303	-0.733	0.612
Air quality	0.529	-0.121	0.315	0.776	0.062	0.838
Road quality	0.591	-0.053	-0.073	-0.436	0.673	0.647
Tel_subscription	0.013	0.699	0.692	-0.180	0.002	0.456
Overall KMO						0.642

Component	PC1	PC2	PC3	PC4
Eigenvalue	2.619	1.034	0.283	0.064
Proportion	0.655	0.259	0.071	0.016
Cumulative	0.660	0.913	0.984	1.000

Variables	Vector 1	Vector 2	Vector 3	Vector 4	KMO
Document to export	0.467	0.537	0.675	-0.196	0.517
Document to import	0.477	0.515	-0.668	0.248	0.486
Time to export	0.536	-0.445	-0.215	-0.685	0.504
Time to import	0.517	-0.498	0.230	0.657	0.493
Overall KMO					0.500
Entry cost index					
Component	PC1	PC2	PC3		
Eigenvalue	1.658	0.842	0.500		
Proportion	0.553	0.281	0.167		
Cumulative	0.553	0.833	1.000		
Variables	Vector 1	Vector 2	Vector 3		KMO
entry_cost	0.442	0.894	0.067		0.730
entry_procedure	0.627	-0.362	0.690		0.557
entry_time	0.641	-0.263	-0.721		0.553
Overall KMO				0.576	

Notes: KMO indicates Kaiser-Meyer-Olkin Measure test of sampling adequacy. PCs indicate principal components.

B. 2 Summary of major variables

Table 8: Summary statistics of variables

Variables	Obs.	Mean	Std.dev.	Min	Max
$Distw_{ij}$	113565	7080.2	3831.6	188.3	19603.1
Pop_{it}	113565	19.7	26.9	0.1	177.5
Pop_{jt}	113565	37.6	137.2	0.0	1364.3
$Gdpc_{it}$	113393	1985.7	2705.5	112.2	16185.9
$Gdpc_{jt}$	111410	11890.8	17012.6	112.2	100819.0
$Area_i$	113565	601614.5	611652.8	455.0	2500000.0
$Area_j$	113565	747532.5	2012407.0	25.0	17000000.0
$Colony_{ij}$	113565	0.0	0.1	0	1
$Comrelig_{ij}$	113565	0.2	0.2	0	1
WTO_i	113565	0.8	0.4	0	1
WTO_j	113565	0.8	0.4	0	1
RTA_i	113565	0.1	0.3	0	1
$Landlocked_i$	113565	0.7	0.4	0	1
$Comcol_{ij}$	113565	0.1	0.4	0	1
$Eco\_Instituions_{it}$	83974	0.5	0.2	0	1
$Border\_Transport_{it}$	71909	0.3	0.2	0	1
$Physical\_communication_{it}$	43645	0.5	0.2	0	1
$Tariff_{ji}$	46095	0.1	0.0	0	1
$cocur_{ij}$	113565	0.0	0.1	0	1

Notes: Eco_instituionsit, border_transportit and physical_communicationit are rescaled to minimum 0 and maximum 1.

B.3 Correlations

Table 9: correlations institutional quality, transport and border efficiency, physical and communication infrastructure indicators

	$efree_{it}$	$stab_{it}$	rq_{it}	ge_{it}	cc_{it}	rl_{it}	va_{it}		
Economic freedom ($free_{it}$)	1								
Absence of violence ($stab_{it}$)	0.302	1							
Regulators quality (rq_{it})	0.544	0.570	1						
Government Effectiveness (ge_{it})	0.365	0.567	0.860	1					
Control corruption (cc_{it})	0.380	0.655	0.777	0.842	1				
Rule of law (rl_{it})	0.460	0.712	0.862	0.881	0.873	1			
Voice and accountability (va_{it})	0.138	0.395	0.569	0.446	0.411	0.465	1		
	Qr_{it}	Qa_{it}	Qro_{it}	Tx_{it}	Ti_{it}	Tel_{it}	Mob_{it}	Di_{it}	Dx_{it}
Quality of railway (Qr_{it})	1								
Quality of air transport (Qa_{it})	0.704	1							
Quality of road (Qro_{it})	0.919	0.690	1						
Time to export (Tx_{it})	-0.195	-0.231	-0.192	1					
Time to import (Ti_{it})	-0.193	-0.286	-0.191	0.918	1				
Telecommunication (Tel_{it})	-0.065	-0.081	-0.083	-0.295	-0.140	1			
Mobile phone (Mob_{it})	-0.131	-0.054	-0.078	-0.368	-0.323	0.277	1		
Document to import (Di_{it})	0.189	0.098	0.214	0.318	0.461	-0.214	-0.295	1	
Document to export (Dx_{it})	0.013	-0.080	0.070	0.494	0.508	-0.320	-0.215	0.738	1

Appendix C: Regression results of various specifications

Table 10: The marginal effects of quality of economic institutions, transport efficiency and infrastructure on trade flow (two-step Heckman)

Variables	I(a) Outcome	I(b) Selection	II(a) Outcome	II(b) Selection
$lngdpc_{it}$	1.266***	0.191***	2.101***	0.585***
	(0.048)	(0.008)	(0.134)	(0.028)
$lngdpc_{jt}$	1.018***	0.209***	0.980***	0.212***
	(0.039)	(0.006)	(0.035)	(0.006)
$lnpop_{it}$	2.240***	0.370***	2.252***	0.398***
	(0.072)	(0.009)	(0.067)	(0.009)
$lnpop_{jt}$	1.533***	0.235***	1.491***	0.238***
	(0.048)	(0.006)	(0.043)	(0.006)
$lndis_{ij}$	-0.699***	-0.041***	-0.692***	-0.036***
	(0.053)	(0.011)	(0.049)	(0.011)
$comrelig_{ij}$	2.158*	0.628**	2.834***	0.910***
	(1.110)	(0.261)	(1.045)	(0.265)
$comcol_{ij}$	0.330***	-0.005	0.368***	0.007
	(0.111)	(0.025)	(0.104)	(0.025)
$colrel_{ij}$	-0.147	-0.665***	-0.008	-0.664***
	(0.373)	(0.101)	(0.346)	(0.101)
WTO_i	1.815***	0.458***	1.727***	0.464***
	(0.128)	(0.019)	(0.116)	(0.019)
WTO_i	-0.229*	-0.119***	-0.363***	-0.137***
	(0.126)	(0.027)	(0.121)	(0.028)
$lnarea_j$	-0.185***	0.004	-0.186***	0.004
	(0.022)	(0.005)	(0.020)	(0.005)
$lnarea_i$	-0.623***	-0.121***	-0.589***	-0.099***
	(0.041)	(0.008)	(0.038)	(0.008)
$lnentrycost_{it}$		-0.216***		-0.284***
		(0.028)		(0.029)
lan_{ij}	1.982***	0.416***	1.852***	0.406***
	(0.113)	(0.023)	(0.102)	(0.023)
Sea_i	0.639***	0.037**	1.198***	0.141***
	(0.085)	(0.018)	(0.102)	(0.024)
RTA_{ij}	3.129***	0.610***	3.006***	0.601***
	(0.130)	(0.032)	(0.117)	(0.032)
$cocur_{ij}$	2.830***	0.407***	2.723***	0.406***
	(0.233)	(0.052)	(0.216)	(0.052)
$ln(econ\_institutions_{it})$	0.421***	0.053***	-4.617***	-1.520***
	(0.061)	(0.014)	(0.471)	(0.101)
$Ln(border\_transport_{it})$	-0.068***	-0.013***	1.123***	-0.281***
	(0.021)	(0.005)	(0.398)	(0.092)
$ln(physical\_communication_{it})$	0.619***	0.108***	-0.828***	-0.444***
	(0.047)	(0.010)	(0.226)	(0.054)
$ln(econ\_institutions_{it})* lngdpc_i$			0.721***	0.220***
			(0.069)	(0.014)
$Ln(border\_transport_{it})*lngdpc_i$			-0.132***	0.029***
			(0.043)	(0.010)
$ln(physical\_communication_{it})*lngdpc_i$			0.180***	0.068***
			(0.030)	(0.007)
Cons.	-5.917***	-2.046***	-12.423***	-5.557***
	(0.880)	(0.144)	(1.497)	(0.290)

Mills ratio	5.439***	5.058***
	(0.327)	(0.285)
No. obs.	37,409	37,409
Censored obs.	14,956	14,956
Wald χ2	2087.95	2549.17

Notes: i=1,…, 44 and j=1,…,173 indicate the reporter and partner country, respectively. All specifications include time fixed effects and MRT corrections for bilateral trade cost variables. Standard errors are reported in parenthesis. ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

Table 11a: The impacts of separate physical infrastructure indicators on trade flow of African countries (twostep Heckman)

Variables	I (a) Outcome	I (b) Selection	II(a) Outcome	II(b) Selection	III(a) Outcome	III(b) Selection
$lngdpc_{it}$	0.913***	0.213***	1.158***	0.293***	1.004***	0.111***
	(0.044)	(0.015)	(0.035)	(0.014)	(0.035)	(0.009)
$lngdpc_{jt}$	0.805***	0.253***	0.735***	0.341***	1.073***	0.234***
	(0.025)	(0.007)	(0.026)	(0.009)	(0.028)	(0.005)
$lnpop_{it}$	1.343***	0.311***	1.559***	0.391***	1.648***	0.244***
	(0.047)	(0.015)	(0.039)	(0.014)	(0.046)	(0.009)
$lnpop_{jt}$	1.325***	0.299***	1.367***	0.373***	1.527***	0.261***
	(0.032)	(0.009)	(0.032)	(0.010)	(0.035)	(0.005)
$lndis_{ij}$	-0.803***	-0.110***	-0.686***	-0.100***	-0.727***	-0.039***
	(0.040)	(0.015)	(0.045)	(0.017)	(0.038)	(0.009)
$comrelig_{ij}$	0.963	1.448***	3.476***	0.982**	2.790***	0.615***
	(0.753)	(0.333)	(0.866)	(0.400)	(0.775)	(0.215)
$comcol_{ij}$	0.741***	0.016	0.753***	0.042	0.641***	0.066***
	(0.083)	(0.031)	(0.095)	(0.037)	(0.080)	(0.020)
$colrel_{ij}$	0.748***	-0.599***	1.856***	-0.279	0.284	-0.614***
	(0.265)	(0.156)	(0.259)	(0.204)	(0.272)	(0.087)
WTO_i	0.547***	0.453***	0.461***	0.422***	1.321***	0.422***
	(0.083)	(0.025)	(0.084)	(0.028)	(0.087)	(0.016)
WTO_i	2.138***	0.412***	0.280***	-0.078*	1.078***	0.190***
	(0.112)	(0.041)	(0.101)	(0.042)	(0.067)	(0.016)
$lnarea_j$	-0.191***	-0.021***	-0.272***	-0.034***	-0.160***	-0.002
	(0.017)	(0.006)	(0.018)	(0.007)	(0.016)	(0.004)
$lnarea_i$	-0.403***	-0.102***	-0.037*	-0.024***	-0.327***	-0.053***
	(0.046)	(0.017)	(0.022)	(0.009)	(0.025)	(0.006)
$lnentrycost_{it}$		-0.572***		-0.691***		-0.281***
		(0.057)		(0.048)		(0.026)
lan_{ij}	1.201***	0.340***	1.125***	0.487***	1.670***	0.354***
	(0.074)	(0.030)	(0.079)	(0.034)	(0.076)	(0.018)
Sea_i	1.549***	0.169***	2.724***	0.952***	1.067***	0.185***
	(0.094)	(0.033)	(0.093)	(0.053)	(0.070)	(0.016)
RTA_{ij}	2.337***	0.561***	1.395***	0.522***	2.986***	0.594***
	(0.082)	(0.045)	(0.085)	(0.031)	(0.094)	(0.028)
$cocur_{ij}$	2.604***	0.741***	2.336***	0.617***	3.088***	0.455***
	(0.191)	(0.085)	(0.194)	(0.090)	(0.240)	(0.067)
$ln(railway_{it})$	0.313***	0.090***				
	(0.028)	(0.013)				
$ln(road_{it})$			0.072**	0.070***		
			(0.034)	(0.015)		
$ln(airway_{it})$					0.199***	0.054***
					(0.015)	(0.003)
_cons	-5.593***	-3.268***	-7.112***	-4.941***	-10.106***	-2.816***
	(0.816)	(0.289)	(0.631)	(0.208)	(0.631)	(0.103)
Mills ratio		2.212***		1.211***		4.946***
		(0.198)		(0154)		(0.227)
No. obs.		22,594		19,190		52,859
Censored obs.		7,236		7,894		19,143
Wald $\chi 2$		3604.04		3767.56		4090.98

Notes: i=1,…, 44 and j=1,…,173 indicate the reporter and partner country, respectively. All specifications include time fixed effects and MRT corrections for bilateral trade cost variables. Standard errors are reported in parenthesis. ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

Table 11b: The impacts of separate border and transport efficiency and communication infrastructure on trade flow of African countries (twostep Heckman)

Variables	Iv(a) Outcome	iv(b) Selection	v (a) Outcome	v(b) Selection	v (a) Outcome	v(b) Selection
$lngdpc_{it}$	1.189***	0.181***	1.162***	0.187***	1.209***	0.189***
	(0.030)	(0.008)	(0.024)	(0.006)	(0.030)	(0.006)
$lngdpc_{jt}$	0.978***	0.250***	0.989***	0.254***	1.057***	0.241***
	(0.020)	(0.004)	(0.020)	(0.004)	(0.027)	(0.004)
$lnpop_{it}$	1.780***	0.315***	1.823***	0.332***	1.850***	0.318***
	(0.031)	(0.007)	(0.030)	(0.006)	(0.040)	(0.007)
$lnpop_{jt}$	1.483***	0.275***	1.501***	0.280***	1.574***	0.265***
	(0.024)	(0.004)	(0.024)	(0.004)	(0.032)	(0.005)
$lndis_{ij}$	-0.628***	-0.024***	-0.642***	-0.026***	-0.577***	-0.009
	(0.027)	(0.008)	(0.027)	(0.008)	(0.035)	(0.008)
$Comrelig_{ij}$	1.114**	0.015	0.724	-0.058	0.541	0.080
	(0.557)	(0.177)	(0.553)	(0.176)	(0.727)	(0.191)
$comcol_{ij}$	0.474***	0.052***	0.441***	0.039**	0.474***	0.031*
	(0.055)	(0.016)	(0.055)	(0.016)	(0.072)	(0.017)
$colrel_{ij}$	0.719***	-0.553***	0.680***	-0.566***	0.508**	-0.552***
	(0.184)	(0.072)	(0.184)	(0.073)	(0.244)	(0.076)
WTO_i	1.142***	0.412***	1.138***	0.413***	1.440***	0.426***
	(0.058)	(0.013)	(0.058)	(0.013)	(0.079)	(0.014)
WTO_i	0.424***	0.057***	0.635***	0.119***	0.555***	0.084***
	(0.048)	(0.014)	(0.047)	(0.014)	(0.059)	(0.014)
$lnarea_j$	-0.204***	-0.006**	-0.208***	-0.008**	-0.212***	-0.007**
	(0.011)	(0.003)	(0.011)	(0.003)	(0.014)	(0.003)
$lnarea_i$	-0.308***	-0.051***	-0.356***	-0.066***	-0.205***	-0.034***
	(0.016)	(0.005)	(0.015)	(0.004)	(0.020)	(0.005)
$lnentrycost_{it}$		-0.307***		-0.288***		-0.214***
		(0.019)		(0.019)		(0.021)
lan_{ij}	1.621***	0.402***	1.642***	0.411***	1.808***	0.407***
	(0.052)	(0.015)	(0.052)	(0.015)	(0.070)	(0.016)
Sea_i	3.205***	0.731***	3.174***	0.733***	0.701***	0.094***
	(0.068)	(0.023)	(0.068)	(0.023)	(0.68)	(0.016)
RTA_{ij}	1.326***	0.247***	1.295***	0.248***	3.237***	0.680***
	(0.045)	(0.012)	(0.045)	(0.012)	(0.89)	(0.025)
$cocur_{ij}$	2.891***	0.516***	3.055***	0.556***	3.244***	0.520***
	(0.120)	(0.039)	(0.123)	(0.040)	(0.161)	(0.042)
$Ln(ict\_mob_{it})$	0.078***	0.033***				
	(0.017)	(0.005)				
$Ln(ict\_tel_{it})$			0.200***	0.048***		
			(0.014)	(0.004)		
$Trade\_document_{it}$					-0.063***	-0.028***
					(0.013)	(0.003)
$Trade\_time_{it}$					-0.037***	-0.007***
					(0.002)	(0.001)
_cons	-9.390***	-3.459***	-8.942***	-3.443***	-12.032***	-3.795***
	(0.453)	(0.082)	(0.448)	(0.079)	(1.334)	(0.272)
Mills ratio	3.936***		3.969***		4.861***	
	(0.142)		(0.142)		(0.198)	
No. obs.	83,168		82,678		70,255	
Censored obs.	34,195		33,696		29,602	
Wald $\chi 2$	7896.63		7921.96		4635.07	

Notes: i=1,…, 44 and j=1,…,173 indicate the reporter and partner country, respectively. All specifications include time fixed effects and MRT corrections for bilateral trade cost variables. Standard errors are reported in parenthesis. ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

Table 12: The impacts of border and transport efficiency, quality of economic institutions, physical and communication infrastructure on trade flow of African countries (PPML)

Variables	I (a) Outcome	II(a) Outcome	III(a) Outcome	IV(a) Outcome
$lngdpc_{it}$	0.478***	0.401	0.325	0.513
	(0.175)	(0.256)	(0.222)	(0.470)
$lngdpc_{jt}$	0.683***	0.654***	0.655***	0.591***
	(0.018)	(0.020)	(0.048)	(0.026)
$lnpop_{it}$	-2.801***	-3.482***	-6.590**	-6.614***
	(0.952)	(1.298)	(2.637)	(2.408)
$lnpop_{jt}$	0.988***	1.014***	1.018***	0.993***
	(0.029)	(0.033)	(0.073)	(0.043)
$lndis_{ij}$	-0.855**	-0.779***	-1.000***	-0.802***
	(0.050)	(0.061)	(0.115)	(0.078)
$comrelig_{ij}$	-0.326***	-0.404***	-0.670**	-0.404***
	(0.110)	(0.123)	(0.323)	(0.143)
$comcol_{ij}$	0.048	-0.014	0.112	-0.053
	(0.114)	(0.122)	(0.231)	(0.178)
$colrel_{ij}$	0.152	0.101	0.577***	0.383***
	(0.094)	(0.107)	(0.202)	(0.107)
WTO_i	0.938***	0.929***	0.950***	0.895***
	(0.071)	(0.084)	(0.230)	(0.106)
WTO_i	8.186***	0.222	-21.846**	-22.216**
	(2.193)	(0.426)	(9.392)	(9.232)
$lnarea_j$	0.034*	-0.026	-0.013	-0.010
	(0.019)	(0.029)	(0.046)	(0.26)
$lnarea_i$	2.666***	2.979***	5.214***	5.628***
	(0.694)	(0.943)	(1.901)	(1.761)
lan_{ij}	0.487***	0.525***	0.271	0.362***
	(0.083)	(0.095)	(0.174)	(0.111)
Sea_i	15.028***	8.357***	-7.931*	-8.507*
	(4.052)	(2.556)	(4.190)	(4.451)
RTA_{ij}	0.450***	0.424***	0.208	0.435***
	(0.075)	(0.086)	(0.188)	(0.110)
$cocur_{ij}$	0.849***	0.899***	0.213	0.335
	(0.132)	(0.146)	(0.371)	(0.231)
$ln(eco\_institutionst_i)$	0.303*			0.098
	(0.177)			(0.336)
$ln(border\_transport_{it})$		0.129**		0.185**
		(0.051)		(0.076)
$ln(physical\_communication_{it})$			0.509**	0.562***
			(0.216)	(0.158)
_cons	-46.824***	-41.420***	-43.086***	-50.529***
	(12.170)	(13.566)	(14.260)	(15.542)
Obs.	73,401	61,341	37289	33395
Pseudo R^2	0.466	0 .463	0.472	0.471

Notes: i=1,…, 44 and j=1,…,173 indicate the reporter and partner country, respectively. Standard errors are reported in parenthesis. ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

Table 13: The impacts of border and transport efficiency, quality of economic institutions, physical and communication infrastructure on trade flow of African countries (twostep Heckman)

Variables	I (a) *Outcome*	I (b) *Selection*	II(a) *Outcome*	II(b) *Selection*	III(a) *Outcome*	III(b) *Selection*
$lngdpc_{it}$	1.353***	0.233***	1.316***	0.215***	1.536***	0.274***
	(0.043)	(0.010)	(0.053)	(0.011)	(0.078)	(0.012)
$lngdpc_{jt}$	0.901***	0.213***	0.930***	0.207***	0.827***	0.155***
	(0.030)	(0.006)	(0.037)	(0.007)	(0.045)	(0.009)
$lnpop_{it}$	1.822***	0.329***	1.842***	0.299***	2.098***	0.336***
	(0.051)	(0.011)	(0.059)	(0.011)	(0.092)	(0.014)
$lnpop_{jt}$	1.463***	0.235***	1.522***	0.234***	1.442***	0.183***
	(0.037)	(0.008)	(0.046)	(0.008)	(0.058)	(0.010)
$lndis_{ij}$	-0.763***	-0.071***	-0.775***	-0.063***	-1.038***	-0.162***
	(0.049)	(0.013)	(0.059)	(0.014)	(0.090)	(0.017)
$comrelig_{ij}$	1.986***	0.822***	1.452	0.628**	2.700*	0.979**
	(0.949)	(0.299)	(1.128)	(0.307)	(1.634)	(0.399)
$comcol_{ij}$	0.645***	0.072***	0.508***	0.023	0.206	-0.074**
	(0.101)	(0.027)	(0.119)	(0.028)	(0.164)	(0.036)
$colrel_{ij}$	0.463	-0.625***	0.392	-0.585***	0.029	-0.629***
	(0.286)	(0.096)	(0.340)	(0.098)	(0.464)	(0.123)
WTO_i	0.953***	0.327***	1.091***	0.324***	1.312***	0.356***
	(0.102)	(0.023)	(0.125)	(0.025)	(0.178)	(0.032)
WTO_i	0.528***	0.057*	1.001***	0.157***	-0.155	-0.144***
	(0.106)	(0.030)	(0.110)	(0.025)	(0.195)	(0.042)
$lnarea_j$	-0.202***	0.006	-0.219***	0.001	-0.202***	0.016**
	(0.020)	(0.006)	(0.024)	(0.006)	(0.033)	(0.008)
$lnarea_i$	-0.261***	-0.058***	-0.161***	-0.033***	-0.507***	-0.092***
	(0.027)	(0.007)	(0.034)	(0.008)	(0.048)	(0.010)
$lnentrycost_{it}$		-0.139***		-0.166***		-0.182***
		(0.035)		(0.035)		(0.044)
lan_{ij}	1.541***	0.372***	1.725***	0.400***	1.819***	0.391***
	(0.088)	(0.024)	(0.109)	(0.025)	(0.152)	(0.033)
Sea_i	1.695***	0.326***	1.701***	0.319***	1.254***	0.194***
	(0.085)	(0.020)	(0.102)	(0.021)	(0.137)	(0.029)
RTA_{ij}	3.056***	0.642***	3.118***	0.616***	2.986***	0.555***
	(0.104)	(0.033)	(0.126)	(0.035)	(0.170)	(0.042)
$cocur_{ij}$	2.938***	0.454***	3.179***	0.462***	2.589***	0.354***
	(0.211)	(0.064)	(0.264)	(0.071)	(0.370)	(0.084)
$lntariff_{ijt}$	-0.068	-0.012	-0.087	-0.007	-0.388	-1.338***
	(0.047)	(0.086)	(0.331)	(0.084)	(0.364)	(0.406)
$ln(eco\_institutionst_i)$	0.109*	0.049***				
	(0.065)	(0.018)				
$ln(border\_transport_{it})$			-0.137***	-0.021***		
			(0.023)	(0.005)		
$ln(physical\_$ $communication_{it})$					0.244***	-0.014
					(0.064)	(0.015)
_cons	-10.494***	-3.437***	-13.301***	-3.723***	-7.417***	-2.595***
	(0.784)	(0.144)	(0.992)	(0.145)	(1.256)	(0.209)
Mills ratio	5.098***		5.732***		6.151***	
	(0.308)		(0.374)		(0.546)	
No. obs.	35,361		31,555		19,524	
Censored obs.	8,149		7,722		4,685	
Wald $\chi 2$	3159.68		2208.460		1250.10	

Notes: i=1,…, 44 and j=1,…,173 indicate the reporter and partner country, respectively. All specifications include time fixed effects and MRT corrections for bilateral trade cost variables. Standard errors are reported in parenthesis. ***, ** and * indicate significance at 1%, 5% and 10%, respectively.