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Does Africa Trade Less than it Should, and If So, Why?

The Role of Market Access and Domestic Factors

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Contents

List of Tables

List of Figures

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ABSTRACT

This paper addresses the question of whether Africa is an undertrading continent. We answer this question using a much-improved data set for obtaining predicted trade and by employing methods that correct for bias in estimates of undertrading. Our results indicate that globally Africa is an underexporter in our preferred Heckman specification. This result is robust to the addition of various controls and the application of variants of the gravity model of trade. We also looked for explanations for Africa's undertrading. We found that accounting for transport and communication infrastructure reduced the undertrading effect for Africa, and in some specifications of the gravity model, the under-trading effect vanished altogether. Results from a semiparametric model provided evidence of significant nonlinear impacts from infrastructure, and the effects for a large number of African countries was significant and compared favorably with the marginal effects of infrastructure in countries on other continents and in comparable income brackets. Using this model we also found evidence of complementarity across transport and communication infrastructure, implying that much greater impacts will be likely if the infrastructure are developed jointly rather than in isolation.

Keywords: Gravity model; undertrading; trade related infrastructure; market access

1. INTRODUCTION

In debates about globalization, the utilization of trading opportunities by Africa has always been under contention (e.g., Sachs and Warner 1997; Rodrik 1998). Africa's share in world exports has declined sharply over time from about 5.5 percent in 1975 to about 2.5 percent in 2002 (World Bank 2005), which indicates an increasing marginalization of Africa in world trade. However, this raises the question of whether the observed pattern of exports from Africa is consistent with the predicted or expected level of trade.

Gravity models of trade that explain trade as a function of income levels of partners, their trading costs (captured by distance, trade barriers, and other variables that determine trading costs, such as language barriers) have been found to explain observed levels of trade quite well. The difference between actual and predicted trade classifies countries as undertrading, overtrading, or normal trading, depending on whether the difference is negative, positive, or statistically not different from zero (see Subramanian and Tamirisa 2001). Because undertrading is defined relative to predicted trade, it is model and data specific.

However, the issue of undertrading by Africa has remained highly debated in the literature, with results depending on the region considered, the period included, or the methodology used (different variants of gravity model) for analysis. Sachs and Warner (1997) argue that Africa has missed out on globalization. The World Bank (2000) states that Africa's loss in world trade has cost it almost $70 billion a year, reflecting a failure to diversify into new products as well as a falling market share for traditional goods. Subramanian and Tamirisa (2001) also found support for undertrading by Africa.

On the other side, a relatively well-developed literature argues that Africa has been trading in line with predicted trade or even overtrading. In a pioneering study Foroutan and Pritchett (1993) found no evidence that flows of trade within Sub-Saharan Africa (SSA) were differentially low either because of policy or infrastructural weakness and observed that trade tallied with of predicted levels. The low degree of trade among the Sub-Saharan African countries could be explained by the countries' low levels of GDP. Rodrik (1998) supports this view, arguing that Africa participates in international trade as much as can be expected according to international benchmarks relating trade volumes to income levels, country size, and geography.

Coe and Hoffmaister (1998) provide evidence in favor of Rodrik's results by estimating a gravity model of bilateral trade between developing and industrial countries. Their results indicate that in the early 1990s Africa actually overtraded compared with developing countries in other regions. However, Coe and Hoffmaister point to a trend decline in African north–south trade over the past 25 years in marked contrast to the trend increase in Latin America and the broadly stable pattern in Asia. Subramanian and Tamirisa (2001) however critique Coe and Hoffmaister for not controlling for a key variable in their analysis: the preferential trading arrangement between the European Union and Africa under the Lomé Convention.

In this paper we revisit the question of whether or not Africa is an undertrading continent. We answer the question using an improved data set to obtain predicted levels of trade and by employing methods that correct for bias in estimates of undertrading. The bias originates from zero trade particularly by not treating the sample of trading partners with positive trade as a selected one. Further, the literature previously cited focuses on exploring whether or not Africa undertrades but does not explain rigorously the reasons for undertrading (if obtained). We attempt to answer a question that has not been formally addressed in the literature: What might explain Africa's undertrading?

To study the issue of undertrading, we obtained predicted levels of trade using the Market Access Map (MAcMap) database developed jointly by the International Trade Center, the United Nations Conference on Trade and Development, and the World Trade Organization (Bouët et al. 2008). Compared with other trade protection measuring tools, the MAcMap database contains a more extensive set of trade protection measures—namely, the ad valorem equivalent (AVE) of specific tariffs, the AVE of tariff rate quotas, and the AVE of antidumping duties. In addition, by accounting for all regional agreements and preferential schemes, the MAcMap allows for the capture of country-specific levels of market access.

We found that both the levels and distribution of protection across countries vary significantly with the breadth of the measures. This points to the possibility of serious measurement error when only a narrow measure of protection (ad valorem tariffs) is used in gravity models of trade, as has been the convention. Moreover, we found that within Africa, market access varies widely across countries, even those covered by the same preferential arrangement, mainly because of the composition of exports. Thus, use of dummy membership variables to capture the effect of preferential trading arrangements again amounts to measurement error in market access variables. The measure of trade protection used in our study minimized these two measurement errors.

In addressing the question of whether or not Africa undertrades, we used the Heckman sample selection method to account for zero trade flows. We found evidence that globally Africa is an underexporter but not an underimporter. We further tested for robustness of this result using the conventionally employed variants of the gravity model: the log linear and Tobit specifications. More importantly, underexporting by Africa does not hold in a sample of exporting countries that are low income (based on the World Bank classification). This motivated us to look at factors associated with countries being low income that could explain undertrading by Africa in a global sample. Trade-related infrastructure is one such factor that is likely to be a significant determinant of trade costs and hence exports. We found that accounting for transport and communication infrastructure in the same sample of countries in which Africa emerges as an undertrader reduces the undertrading effect. In fact, in some specifications undertrading by Africa vanishes altogether.

The role of infrastructure in enhancing trade has been widely discussed in policy circles and in descriptive literature but has rarely been studied rigorously in formal literature. Bougheas et al. (1999) and Francois and Manchin (2007) estimate the effect of infrastructure on trade by including infrastructure linearly in a gravity model. However, quantifying the true impact of infrastructure on trade is difficult, mainly because of the interactive nature of various types of infrastructure. Thus, the impact of greater phone connectivity depends on the supporting road infrastructure and vice versa. Most importantly, the precise way this dependence among infrastructure types occurs is unknown, and no a priori theoretical basis for presuming the functional forms for such interactions exists. In our study, therefore, we employed a semiparametric variant of the gravity model that allows for unknown nonlinear impacts of infrastructure on trade and complementarity among several infrastructure variables. For numerous African countries we found that the marginal impacts of infrastructure on trade are significant and lie in the range of estimated impacts for most non-African developing countries. Our semiparametric model revealed evidence for complementarity across various types of infrastructure. Thus, higher returns from investment in infrastructure in Africa or elsewhere can be realized when infrastructures are developed jointly rather than in isolation.

The paper is organized into six sections and an appendix. Section 2 presents methodology based on gravity models. Section 3 discusses the data and summary statistics for the econometric analysis. Section 4 presents the results and interpretations. Section 5 discusses the semiparametric model and the results on the impacts of infrastructure on trade for Africa. In Section 6 we present our conclusions and suggest policy implications. The appendix contains tables and figures that present supplementary descriptive data and econometric results.

2. METHODOLOGY

We adopted the model developed by Fontagné et al. (2002), augmented for the role of infrastructure in determining trade costs. In the model all goods are differentiated by the place of origin, and each region produces only one good; the supply of each good is fixed; and consumers have identical and homothetic preferences represented by a constant elasticity of substitution (CES) utility function. The consumption of a good produced in country i by agents in country j is denoted by c_{ij}, and the utility functions of the agents in country j are denoted by U_j.

The agents in country j maximize U_j, subject to the budget constraint according to the following equation:

$$U_j = \left(\sum_i \beta_i^{1/\sigma} c_{ij}^{(\sigma-1)/\sigma} \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

Those utility functions are subject to the following budget constraint:

$$\sum_i p_{ij} c_{ij} = y_j , \tag{2}$$

where σ is the elasticity of substitution between all goods, β_i is a distribution parameter, and p_{ij} is the price in j of the good produced in i. If p_i is the exporter's supply price, then $p_{ij} = p_i \tau_{ij}$,where τ_{ij} is greater than or equal to 1 and includes trade costs (transportation costs, tariffs, administrative costs, information costs, etc.) and is of iceberg type. The total income of i is $y_i = p_i Q_i$, and the share of country i in world income y^W is s_i.

Maximizing equation (1) subject to equation (2) and performing a few transformations results in

$$x_{ij} = \frac{1}{\tau_{ij}} \frac{y_i y_j}{y^W} \frac{\left(\frac{\tau_{ij}}{\tilde{\Pi}_j} \right)^{1-\sigma}}{\sum_k s_k \left(\frac{\tau_{ik}}{\tilde{\Pi}_k} \right)^{1-\sigma}} , \tag{3}$$

where

$$\tilde{\Pi}_j = \left[\sum_i \alpha_i \tau_{ij}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{4}$$

is a CES index of the trade costs in exports from i to j.

Equation (3) implies that the exports from i to j are positively related to the supply capacity of i (i's income y_i) and the demand capacity of j (j's income y_j) and negatively related to trade costs, where trade costs include those borne by i in exporting to all other destinations. Thus, trade costs include multilateral trade resistance terms, as described in Anderson and van Wincoop (2003). This concept implies that in a gravity model, important components include not only bilateral trade costs but also the costs countries incur from trading with rest of the world. The common practice to proxy for multilateral resistance is to include exporter and importer fixed effects in the regressions (see, e.g., Subramanian and Wei 2007). Because we were interested in identifying the effect of a dummy variable for African exporters that does not vary over time, we used cross-sectional gravity regressions (for 2001 and 2004 samples separately and pooled). Even if we had focused on identifying the effect of infrastructure, given the two close periods, there was little variation over time to exploit. Thus, we could not identify coefficients of infrastructure variables (which are nearly time invariant) in the presence of exporter fixed effects.

The alternative approach that we adopted in this study to control for multilateral resistance terms was to include an extensive set of variables that act like a country fixed effects proxy for the price indices. Therefore, we included the distance of the exporter from the rest of the world and the distance of the importer from the rest of the world as explanatory variables. Similarly, we included the protection faced by an exporting country worldwide and the protection imposed by an importing country on the rest of world, both relative to bilateral protection as control variables.

The bilateral trade costs in the presence of infrastructure are given as

$$\tau_{ij} = (1 + t_{ij}) m(I_i) d_{ij}^{\rho}, \tag{5}$$

where t_{ij} is the bilateral import duty applied by country j on exports from i. Transportation costs are assumed to increase with geographic distance between trading countries d_{ij} and vary negatively with the level of infrastructure in the exporting country I_i.[1] In the simplest formulation, where infrastructure is included linearly, the function *m* is $m(I_i) = \frac{1}{I_i}$ (where I denotes infrastructure), and transport costs are specified as $\tau_{ij} = \frac{(1+t_{ij})d_{ij}^{\rho}}{I}$.

In the empirical formulation, extended measures of trade costs can be included; for example, the countries being landlocked and the sharing of a common border or language between trading partners.

The basic linear specification of the gravity equation is given as

$$\ln(X_{ij}) = \beta_0 + \beta_1 \ln(Y_i) + \beta_2 \ln(Y_j) + \gamma \ln(d_{ij}) + \rho \ln(t_{ij}) + \sum_i \theta_i \mu_{ij} + \delta A_{i/j} + \sum_s \eta_s T_i + \sum_{s'} \eta'_{s'} T_j + \sum_i \lambda_i \ln(I_i) + \varepsilon_{ij} \tag{6}$$

where X_{ij} is the average value of annual exports from country i to country j (averaged over three years); Y_i is the real GDP of country i, T_i and T_j are vectors containing s and s′ multilateral trade resistance terms for the exporters and importers; and μ_{ij} is a vector of variables that capture the relationships important for trade, like sharing of a common border among others. The dummy variables A_i and A_j capture, respectively, whether the exporter or the importer in a bilateral trading pair falls in Africa. If A_i and A_j are negative and significant, they capture Africa as an underexporter and underimporter, respectively, and vice versa.

We also estimated other forms of equation (6) to account for zero trade flows. Some studies employ a Tobit estimator to examine bilateral zeros (e.g., Subramanian and Tamirisa 2001). Francois and Manchin (2007) employ the Heckman method to control for sample selection, but their framework does not include an exclusion variable for likelihood of trade. Helpman et al. (2007) use the measures of regulation that raise the entry costs as the exclusion variable, but as they point out it is only available for a

[1] Ideally there could be importer's infrastructure as well. When we included importer infrastructure in some specifications, the results were identical. The results reported here are with exporter infrastructure only, mainly because in a low-income sample the number of observations shrinks considerably while including importing country infrastructure.

very restricted set of countries. The strength of the exclusion variable in Helpman et al. comes from its theoretical underpinning.[2]

Comparing across various approaches to deal with zero flows (the option to omit the zero flows from the sample, various extensions of Tobit estimation, truncated regression, probit regression, and substitutions for zero flows), Linders and de Groot (2006) argue that the choice of method should be based on both economic and econometric considerations. According to the authors, the sample selection model appears to fit both considerations best. Our preferred specification was thus the Heckman specification, where we treated zero trade to imply that the countries that have a positive trade compose a selected sample. The sample selection model allowed us to account for the unobserved selection criterion that leads to positive trade in the current time period. The Heckit estimator combines probit analysis of zero trade flows with OLS analysis of trade volumes.

Most variables that affect whether two countries trade or not are also likely to affect the strength of their trading relationship (e.g., geographical distance). Therefore, it is challenging to select variables that are highly correlated with a country's propensity to export and not correlated with the actual levels of exports. We used the historical frequency of positive trade between two countries as the exclusion variable. Our premise was that the higher the frequency of positive trade in the past, the greater the likelihood of two countries having a nonzero trade flow in the current period. Because our trade flow variable for the current period is an average over three years, the relationship between historical frequency and the likelihood of current trade is likely to be more systematic. Subsequently, we estimated variants of equation (6) on a truncated sample that included only the low-income exporter countries and low-income importer countries.

Without any a priori knowledge of the nature of linkage between trade and infrastructure, the semiparametric framework that we employed for estimating the impact of infrastructure on trade could be meaningful. In the partial linear model, we assumed that the conditional mean has a linear parametric component (the standard gravity model variables) and a nonparametric component (i.e., a function of the levels of infrastructure).

The partial linear model is thus specified as

$$\ln(X_{ij}) = \beta_0 + \beta_1 \ln(Y_i) + \beta_2 \ln(Y_j) + \gamma \ln(d_{ij}) + \rho \ln(t_{ij}) + \sum_i \theta_i \mu_{ij} + \delta A_{i/j} + \sum_s \eta_s T_i + \sum_{s'} \eta'_{s'} T_j + m(I_i) + \varepsilon_{ij} \quad (7)$$

and the partial linear model that controls for sample selection is given as

$$\begin{aligned} \ln(X_{ij}) = \beta_0 + \beta_1 \ln(Y_i) + \beta_2 \ln(Y_j) + \gamma \ln(d_{ij}) + \rho \ln(t_{ij}) + \sum_i \theta_i \mu_{ij} \\ + \delta A_{i/j} + \sum_s \eta_s T_i + \sum_{s'} \eta'_{s'} T_j + \sum_i \omega_i IM_i + m(I_i) + \varepsilon_{ij} \end{aligned} \quad (7a)$$

where IM_i denotes the inverse Mills ratio from the first stage of the Heckman regression, $\varepsilon_{ij} \sim iid(0, \sigma^2)$, and $I = (I_{i1}, I_{i2})'$. The two infrastructure variables that we used in the partial linear model are phone-line density (I_{i1}) and road density (I_{i2}). The definition of other variables is same as in equation (7). Note that the specification in equation (7) nests the specification in equation (6). By first-order Taylor series expansion around some value $(\tilde{I}_1, \tilde{I}_2)$ we get:

$$m(I_{i1}, I_{i2}) = m(\tilde{I}_1, \tilde{I}_2) + m_1^{(1)}(\tilde{I}_1, \tilde{I}_2)(I_{i1} - \tilde{I}_1) + m_2^{(1)}(\tilde{I}_1, \tilde{I}_2)(I_{i2} - \tilde{I}_2) + o(\left|I_i - \tilde{I}_i\right|,$$

[2] Historical entry costs could manifest themselves in a zero or very low historical frequency of positive trade.

where $m_j^{(1)}(\tilde{I}_1, \tilde{I}_2)$ is the first derivative of $m(.)$ with respect to the j^{th} argument. $\tilde{I}_i = (\tilde{I}_1, \tilde{I}_2)'$ and $o(.)$ include terms that are negligible compared with the leading terms.

In the partial linear model, we corrected for sample selection bias by including the Mill's ratio linearly in equation (7). Following the standard sample selection model by Heckman (1979), we imposed the restriction of joint normality, which explains the linear inclusion. Admittedly, there potentially are several more-flexible functional forms we could have considered in this setting. Two obvious ones are that (1) the nonparametric component includes the inverse Mill's ratio along with infrastructure variables, and (2) the inverse Mill's ratio is incorporated as a nonparametric function. Form (1) is a trivial extension of the model considered here, but in form (2) we would have had to consider a specific type of additive semiparametric model that requires a fundamentally different estimation method. For our analysis we only considered the simplest method by which sample selection issue could be tackled, as in equation (7a).

Note that $m_j^{(1)}(\tilde{I}_1, \tilde{I}_2)$ is the marginal effect of the j^{th} infrastructure on average annual exports of any country i, where the effect has been averaged across all trading partners of that particular country. By construction, this marginal effect depends on both infrastructure variables.[3]

The flexible form in the partial linear model also allows us to investigate the existence of complementarity among infrastructure variables in a meaningful way. If we observe that $\hat{m}_j^{(1)}(I_1, \tilde{I}_2) \geq \hat{m}_j^{(1)}(I_1, \overline{I}_2)$ where $\tilde{I}_2 \geq \overline{I}_2$ for all values of I_1 and all pairs $(\tilde{I}_2, \overline{I}_2)$, then this would imply that I_2 complements I_1 globally. However, it is possible that the above condition is satisfied for a subset of values of I_1 and when $(\tilde{I}_2, \overline{I}_2) \in W \subset R^2$. In that case we would have local complementarity, which is more plausible. Thus, it is possible that when the road density is too low, increasing road density may not increase the marginal impact of phone lines on trade, but that beyond a critical level, increases in road density positively affect the marginal impact of phone-line density.[4]

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[3] Roughly, if the plots of $\hat{m}_j^{(1)}$ against the different infrastructure values are close to horizontal line for all j, then it is expected that the true data-generating process is a linear parametric model. More formally, statistical testing of linearity versus a partial linear model can be done using a Generalized Likelihood Ratio test as given by Fan et al. (2001).

[4] Specifying the partial linear model as $P_{ij} = S_{ij}^{'}\beta + m(Z_i) + \varepsilon_{ij}$, we can estimate the parameters and the nonparametric component of this model. One of the established models for obtaining the asymptotic properties of β was given by Robinson (1988), where $m(Z_i)$ is treated as a nuisance parameter and thus not of significance to an empirical researcher. In this paper we use the profile least-squares-based estimator to obtain the estimates of $m(.)$ and $m^1(.)$ respectively. Note that the estimate of marginal impact of interest to us is the vector $\hat{m}^1(Z_i, \hat{\beta})$. The confidence bound for $\hat{m}(Z_i, \hat{\beta})$ and $\hat{m}^1(Z_i, \hat{\beta})$ have been obtained based on Carroll et al. (1997).

3. DATA AND DESCRIPTIVE STATISTICS

The bilateral export data are obtained from the data set BACI (see Gaulier et al., forthcoming), compiled by Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). For the 2001 and 2004 trade flows, we averaged the data over the periods, 1998–2001 and 2002–2004, to control for abnormal trade flows. The distance between the trading partners and whether or not countries share a common border have also been obtained from the CEPII data set. The distance measure here is the bilateral distance between the biggest cities of the two trading partners weighted by the share of the city in the country's population.

We used the data on trade protection from the MAcMap database for the two periods: 2001 and 2004. We captured the country-specific market access by using the actual bilateral tariffs (taking into account the effect of all preferences). This is especially important because our second period of analysis (2004) includes the effect of two large-scale preferential arrangements for Africa: the Everything But Arms (EBA) Initiative developed by the European Union and the African Growth and Opportunity Act (AGOA) established by the United States. We obtained GDP data from the World Development Indicators of the World Bank (2005). The information on the transport and communication infrastructure variables was also obtained from the World Development Indicators. We used the transport variable of road density, defined as the total road length as a proportion of land area and as a proportion of the total population. We measured communication infrastructure in terms of the phone density in the country—namely, mobile and fixed lines per 1,000 people. For the 2001 sample we used the average of the infrastructure data for 1998–2001, and for 2004 we used the average of the infrastructure data for 2001–2004.

Trade costs, both natural (like distance) and human-made, were captured as multilateral trade resistance terms. The multilateral distance for country i was constructed as a weighted sum of the distance from country i to all k countries weighted by their GDPs. Thus, the distance to a richer country gets a higher weight. In that sense the measure captures the remoteness of country i from the world economy.

The import duty we used is a bilateral tariff from the MAcMap database. It includes all preferential schemes and regional agreements prevailing in 2001 and 2004 and other measures of bilateral protection (specific tariffs, tariff rate quotas and anti-dumping duties). The MAcMap database is a three-dimensional database that gives for all vectors (importer/exporter/product) AVE of tariffs from information on either a bound most-favored-nation (MFN) regime, an applied MFN regime, or a preferential regime granted by the importer to the exporter on the product. Tariff information is available at the HS6 level for 163 importing countries, 208 exporting countries, and 5,111 products. Aggregation can be conducted on one, two, or the three dimensions to estimate the average duty applied to a country's imports, the average duty faced by a country's exports, the world average duty on a specific product, or any combination of those three options. The duty used can either be the preferential duty, the MFN applied duty, or the bound duty. The MAcMap weighting scheme aims to avoid the endogeneity bias common in this kind of measurements (following the use of a country's own imports as weights) by using as weights the trade structure of a reference group of countries that have levels of GDP per capita close to the importers (for more details see Bouët et al. 2008).

For the AVE of the nontariff barriers, we drew on Kee et al. (2006), which is available only at a multilateral level. Because including the AVEs of nontariff barriers reduced our sample size significantly, we ran specifications with and without nontariff barrier measures. (Only the results with nontariff barriers included have been reported in the paper.)

The summary statistics for the data are reported in Table 1.[5] The table compares a sample of non-African exporters with African exporters.

[5] The same descriptive statistics for the low-income exporter sample can be requested from the authors.

Some important points emerge from these statistics. On average, African exporters, including a group of low-income exporters, are farther from the economic centers of the world. Note that a much higher proportion of African exporters are landlocked compared with non-African exporters. Africa enjoys greater market access relative to the rest of the world in terms of both tariff and nontariff barriers.

Table 2 present comparisons of various types of infrastructure in Africa and the rest of the world globally. Clearly, the levels of infrastructure in both the 2001 and 2004 samples are lower for Africa. Road infrastructure in particular is slow to change, and significant changes between the two periods were not expected. However, there has been a quantum jump in the phone infrastructure, especially for mobile lines, and it has risen significantly across all countries, including African countries.

Table 1. Summary of data (full sample)

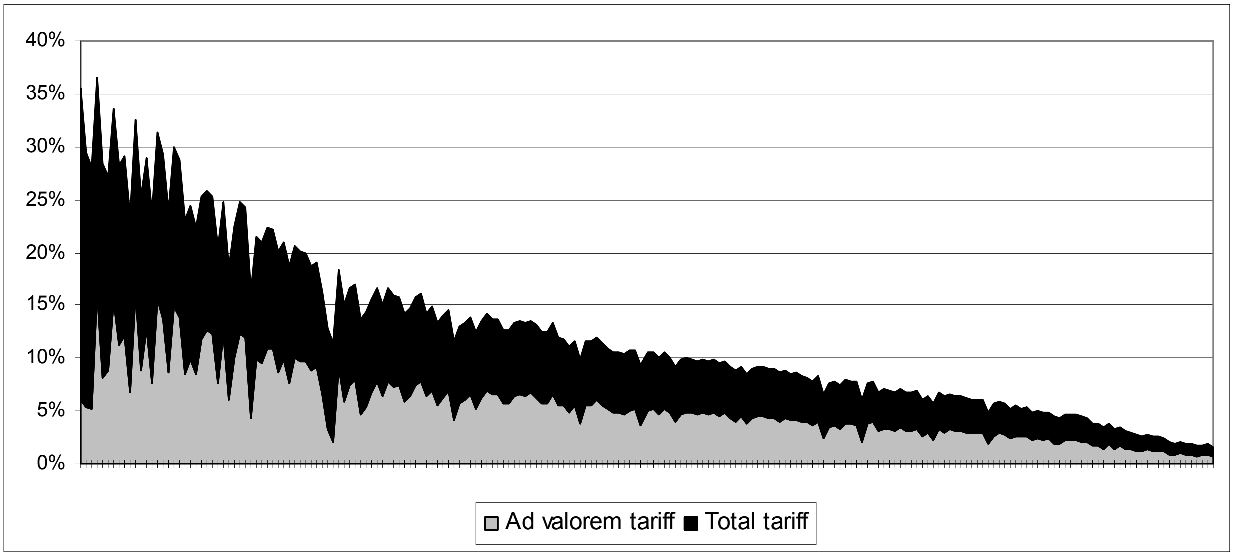
Variable	2001				2004			
	Non-African countries (6,625 observations)		African countries (1,965 observations)		Non-African countries (3,245 observations)		African countries (1,080 observations)	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Log trade	7.23	4.46	4.54	3.68	8.38	3.61	5.78	3.37
Log GDP exporter	24.24	2.32	22.35	1.21	24.45	1.99	22.66	0.96
Log GDP importer	24.14	1.89	24.14	1.90	24.36	1.71	24.45	1.79
Log bilateral distance	8.77	0.80	8.69	0.66	8.64	0.87	8.64	0.64
Log distance exporter from the world	2.05	0.23	2.15	0.11	2.03	0.22	2.15	0.12
Log distance importer from the world	2.10	0.22	2.10	0.22	2.10	0.23	2.09	0.22
Contiguity	0.02	0.14	0.02	0.16	0.03	0.18	0.03	0.17
Common language	0.12	0.32	0.19	0.39	0.11	0.31	0.17	0.38
Colony	0.01	0.11	0.002	0.04	0.005	0.07	0.001	0.06
Landlocked exporter	0.13	0.34	0.35	0.47	0.14	0.34	0.28	0.45
Landlocked importer	0.18	0.38	0.18	0.38	0.12	0.33	0.10	0.30
Log bilateral tariff	-2.49	1.34	-2.84	1.85	-2.50	1.32	-3.05	2.06
Log of NTB protection (data for 2004)	-2.97	1.02	-2.99	1.02	-2.90	0.97	-2.90	0.96

Table 2. Descriptive statistics on infrastructure (full sample)

Variable	2001				2004			
	Non-African countries		African countries		Non-African countries		African countries	
	Mean	Std. dev.	Mean	Std dev.	Mean	Std. dev.	Mean	Std dev.
Road length per unit of population	0.007	0.008	0.003	0.005	0.007	0.007	0.004	0.007
Road length per unit of land area	0.84	1.33	0.13	0.16	0.75	1.31	0.14	0.17
Percent of road paved	58.87	32.53	27.94	24.55	54.65	32.81	26.60	24.15
Phone lines per 1,000 people	79.75	116.65	4.10	11.42	317.02	291.33	31.62	54.91
Main lines per 1,000 people	229.11	227.31	28.31	49.08	192.44	212.82	34.68	64.21

An important concern in the existing studies that estimate trade flows relates to the error in measuring market access. The problem of measurement error in market access is complex owing to different distributions of protection based on the different breadths of included measures of protection. Figure 1 compares the distribution of protection faced by 207 countries in 2001 in the full sample when only the AVEs of tariffs and specific tariffs were included. The fact that the distribution of applied protection changes significantly depending on the breadth of included measures of protection points to potential measurement errors when using incomplete data.

Figure 1. Distribution of protection faced by exports based on breadth of measures (2001)



Source: Author's calculations using the MAcMap HS6 database.

By calculating the average duties faced by exports of various continents,[6] we concluded that Africa's access to foreign markets is on average better than that of America, Asia, or the Pacific. However, wide disparities exist among African countries: 21 African countries have better access than the world average, and 11 of those countries face an average duty on exports that is less than 2 percent: Algeria, Angola, Botswana, Central Africa, Chad, Democratic Republic of the Congo, Equatorial Guinea, Gabon, Lesotho, Liberia, and Libya. In contrast, 32 countries have less favorable access to foreign markets compared with the world average, 13 of which face an average duty on exports that is greater than 10 percent, and Malawi faces a stiff average tariff of 23.1 percent on its exports.

This contrasting picture of African access to foreign markets results from two effects. First, the structure of world protection is unequally distributed among sectors and across importers. Countries that are highly specialized in certain agricultural products—like meat, milk, sugar, or some cereals—or that export to protectionist countries get penalized. We call that a composition effect. However, more preferential access to some countries than to the rest of the world decreases the average duty on exports. That is known as the true preference margin effect. If the composition effect is positive, even without preferences, a country benefits from a tariff lower than the world average. A positive true preference margin implies that the country benefits from preferences relative to the rest of the world, and conversely for a negative true preference margin.

[6] Results are available on request from the authors.

Table 3. Apparent margin and its decomposition for African countries, 2004

Country/zone	Applied duty	Apparent margin	Composition effect	True preference margin
World	4.5			
Africa	4.2	0.3	0.6	-0.3
America	5.3	-0.8	-0.8	0.1
Asia	5.1	-0.6	0.5	-1.1
Europe	3.6	0.9	0.1	0.8
Pacific	10.6	-6.0	-5.3	-0.7
LDC	4.7	-0.1	-1.2	1.1
MIC	5.1	-0.6	0.1	-0.7
OECD	4.1	0.4	0.0	0.4
Chad	1.3	3.3	4.0	-0.8
Congo DR	1.2	3.3	4.5	-1.2
Malawi	23.1	-18.6	-23.1	4.5
Togo	14.9	-10.4	-10.8	0.5

Source: Author's calculations using the MAcMap HS6 database.
Note: Congo DR = Democratic Republic of the Congo; LDC = least developed countries; MIC = middle-income countries; OECD = countries in the Organization for Economic Co-operation and Development.

Table 3 presents this decomposition for country groups and selected African countries. Formally, the extent of trade preferences given to an exporting country *i* (or a geographic zone) is defined by country *i*'s apparent margin (AM_i), which is the difference between the applied duty faced by the world's exports (AD_W) and the applied duty faced by country *i*'s exports (AD_i). These two averages take into account all preferential regimes, but the MAcMap database allows for calculating the same average on the basis of only most-favored-nation duties (i.e., without taking into account preferential schemes and regional agreements). These averages are called $MFND_W$ and $MFND_i$.

Thus, the apparent margin can be rewritten as

$$AM_i = AD_W - AD_i = AD_W - MFND_W + MFND_W - MFND_i + MFND_i - AD_i$$
$$= (MFND_W - MFND_i) + ((MFND_i - AD_i) - (MFND_W - AD_W))$$

The first term in parentheses compares average market accesses for the world and for country *i* without taking into account preferences; it captures the composition effect: if $MFND_W$ is greater than $MFND_i$, that cannot be attributed to preferences given to country *i* but to the composition of exports. The second term captures the difference between the preferential margin given to country *i* ($MFND_i - AD_i$) and the preferential margin given to the world ($MFND_W - AD_W$). That is the true preference margin (see Bouët et al. 2005 for more details and more comprehensive results).

Table 3 shows that if African countries benefit from an average duty on exports that is 0.3 percent lower than that of the rest of the world, the reason is a composition effect that is favorable (0.6 percent). Specializations in products that are not highly taxed throughout the world (oil, gas, and mineral products) have a positive impact on market access in those countries. The average statistic hides significant heterogeneity across countries; exports from Malawi, Swaziland, Togo, Benin, and Mauritius are penalized because of specialization in highly protected products, and preferences compensate only partially (in absolute value, true preference margins are less than the composition effect). On the other hand, the Democratic Republic of the Congo, Chad, Libya, and Lesotho have a positive composition effect. For Africa as a whole, the true preference margin is negative; that is, Africa receives less preference than the rest of the world on average.

4. RESULTS AND INTERPRETATIONS

Table 4 presents the results from our preferred Heckman specification for 2001 and for the full sample. In Table 5 the sample includes only low-income countries. Results for 2004 are presented in Tables 6 and 7. In Tables 4 through 7 the first and third columns present the results of the gravity model estimation in a sample selection framework, and the second and fourth columns present the results of the first-stage estimation of the likelihood of countries trading with each other. The infrastructure variables included in Table 4 are road length as a proportion of population and phones per 1,000 people in the exporting country. Results are robust to alternate measures of transport and communication infrastructure—namely, roads as a percentage of land area, percentage of roads that are paved, and fixed phone lines per 1,000 people (as well as total fixed and mobile lines per 1,000 people). Similarly, results are robust to inclusion of the importing-country infrastructure. Similarly to the exporting-country infrastructure, the importing-country infrastructure variables contribute to the multilateral resistance terms. The same specifications have been run for the pooled sample (not reported here).

Table 4. Heckman regression, 2001 (full sample)

Coefficient	Not including infrastructure		Including infrastructure	
	Logtrade	**Likelihood**	**Logtrade**	**Likelihood**
Exporter's GDP	1.034***	0.326***	1.013***	0.338***
	(0.013)	(0.019)	(0.014)	(0.022)
Importer's GDP	0.896***	0.270***	0.900***	0.280***
	(0.013)	(0.021)	(0.013)	(0.021)
Bilateral distance	-1.325***	-0.258***	-1.330***	-0.283***
	(0.037)	(0.053)	(0.036)	(0.054)
Distance of exporter from world	0.630***	-0.525***	0.725***	-0.391***
	(0.12)	(0.15)	(0.12)	(0.15)
Distance of importer from world	0.438***	-0.272**	0.437***	-0.244*
	(0.11)	(0.13)	(0.11)	(0.13)
Bilateral tariff	0.0684	0.120**	0.0855*	0.143***
	(0.047)	(0.051)	(0.047)	(0.052)
Relative import protection	0.0397	0.0970**	0.0327	0.0896**
	(0.035)	(0.045)	(0.034)	(0.045)
Relative export protection	-0.117***	-0.185***	-0.135***	-0.207***
	(0.037)	(0.034)	(0.037)	(0.034)
NTBs of importer	-0.0676***	-0.0460*	-0.0686***	-0.0502**
	(0.022)	(0.025)	(0.022)	(0.025)
Landlocked exporter	-0.00711	-0.0803	-0.0178	-0.0681
	(0.059)	(0.056)	(0.059)	(0.058)
Landlocked importer	-0.446***	-0.193***	-0.446***	-0.211***
	(0.062)	(0.063)	(0.061)	(0.063)
Contiguity	1.037***	0.0717	1.070***	0.135
	(0.14)	(0.34)	(0.14)	(0.35)

Table 4. Continued

Coefficient	Not including infrastructure		Including infrastructure	
	Logtrade	Likelihood	Logtrade	Likelihood
Common language	0.694***	0.242***	0.682***	0.214***
	(0.065)	(0.082)	(0.065)	(0.082)
Colonial relation	0.698***	4.617	0.709***	4.621
	(0.19)	(0)	(0.19)	(0)
African exporter's dummy	**-0.272*****	**-0.0647**	**-0.0711**	**0.135****
	(0.058)	(0.056)	(0.069)	(0.067)
Historical frequency of trade		2.366***		2.303***
		(0.092)		(0.092)
Constant	-29.30***	-9.583***	-28.88***	-9.519***
	(0.61)	(0.88)	(0.62)	(0.89)
Exporter's phone density			0.0565***	0.0370*
			(0.016)	(0.020)
Exporter's road density			0.0651***	0.138***
			(0.025)	(0.033)
Observations	8563	8563	8563	8563

*, **, *** indicate that the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

Table 5. Heckman regression, 2001 (low-income exporter sample)

Coefficient	Not including infrastructure		Including infrastructure	
	Logtrade	Likelihood	Logtrade	Likelihood
Exporter's GDP	0.819***	0.302***	0.889***	0.353***
	(0.054)	(0.046)	(0.056)	(0.050)
Importer's GDP	0.661***	0.267***	0.682***	0.274***
	(0.043)	(0.034)	(0.041)	(0.035)
Bilateral distance	-0.929***	-0.131	-1.022***	-0.162*
	(0.12)	(0.089)	(0.12)	(0.090)
Distance of exporter from world	1.176*	0.0367	0.971	0.343
	(0.62)	(0.43)	(0.62)	(0.45)
Distance of importer from world	-0.223	-0.654***	-0.201	-0.637***
	(0.28)	(0.20)	(0.28)	(0.20)
Bilateral tariff	0.346***	0.208**	0.448***	0.195**
	(0.12)	(0.089)	(0.12)	(0.091)
Relative import protection	-0.0718	-0.0391	-0.120	-0.0569
	(0.096)	(0.076)	(0.093)	(0.076)
Relative export protection	-0.326***	-0.173***	-0.413***	-0.153***
	(0.088)	(0.057)	(0.088)	(0.059)

Table 5. Continued

Coefficient	Not including infrastructure		Including infrastructure	
	Logtrade	Likelihood	Logtrade	Likelihood
NTBs of importer	-0.0676	-0.0572	-0.0828	-0.0607
	(0.060)	(0.042)	(0.058)	(0.042)
Landlocked exporter	0.0201	-0.117	-0.0675	-0.0290
	(0.12)	(0.083)	(0.13)	(0.098)
Landlocked importer	0.205	-0.155	0.130	-0.168
	(0.17)	(0.11)	(0.17)	(0.11)
Contiguity	1.357***	0.175	1.329***	0.206
	(0.39)	(0.39)	(0.38)	(0.39)
Common language	0.842***	0.172	0.722***	0.159
	(0.16)	(0.13)	(0.15)	(0.13)
Colonial relation	2.354*	3.787	2.663**	3.791
	(1.22)	(0)	(1.18)	(0)
African exporter's dummy	**-0.148**	**0.240****	**0.152**	**0.278*****
	(0.16)	(0.10)	(0.16)	(0.11)
Historical frequency of trade		2.154***		2.119***
		(0.15)		(0.15)
Constant	-21.23***	-10.56***	-19.16***	-12.27***
	(2.29)	(1.65)	(2.41)	(1.79)
Exporter's phone density			0.0714	0.225**
			(0.11)	(0.088)
Exporter's road density			0.474***	0.0334
			(0.076)	(0.054)
Observations	1883	1883	1883	1883

*, **, *** indicate that the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

Table 6. Heckman regression, 2004 (full sample)

Coefficient	Not including infrastructure		Including infrastructure	
	Logtrade	Likelihood	Logtrade	Likelihood
Exporter's GDP	1.091***	0.228***	1.096***	0.305***
	(0.051)	(0.051)	(0.034)	(0.045)
Importer's GDP	0.798***	0.281***	0.810***	0.373***
	(0.061)	(0.054)	(0.041)	(0.038)
Bilateral distance	-1.144***	-0.285**	-1.152***	-0.274***
	(0.14)	(0.13)	(0.091)	(0.099)
Distance of exporter from world	1.044**	-0.569	1.692***	-0.751**
	(0.48)	(0.39)	(0.33)	(0.33)

Table 6. Continued

Coefficient	Not including infrastructure		Including infrastructure	
	Logtrade	Likelihood	Logtrade	Likelihood
Distance of importer from world	0.140	-0.770***	-0.0612	-0.381*
	(0.42)	(0.27)	(0.28)	(0.23)
Bilateral tariff	-0.691***	0.411***	-0.446***	0.301***
	(0.20)	(0.14)	(0.14)	(0.11)
Relative import protection	0.351***	-0.162	0.269***	-0.00415
	(0.13)	(0.10)	(0.090)	(0.080)
Relative export protection	0.360**	-0.180*	0.184*	-0.301***
	(0.16)	(0.11)	(0.11)	(0.088)
NTBs of importer	-0.00272	-0.162**	-0.0782	
	(0.090)	(0.064)	(0.058)	
Landlocked exporter	-0.545**	-0.238*	0.00153	-0.355***
	(0.22)	(0.13)	(0.16)	(0.13)
Landlocked importer	-0.675***	-0.525***	-0.789***	-0.355***
	(0.26)	(0.15)	(0.17)	(0.12)
Contiguity	1.037**	4.458	1.027***	4.928
	(0.52)	(0)	(0.35)	(0)
Common language	0.917***	0.0847	0.828***	0.102
	(0.26)	(0.20)	(0.18)	(0.16)
Colonial relation	0.342	2.328	0.194	2.773
	(1.10)	(0)	(0.74)	(0)
African exporter's dummy	**-0.686*****	**-0.179**	**0.211**	**-0.127**
	(0.22)	(0.13)	(0.17)	(0.13)
Historical frequency of trade		2.558***		2.454***
		(0.24)		(0.19)
Constant	6.128***	5.162***	3.948***	5.482***
	(1.56)	(1.29)	(1.15)	(1.13)
Exporter's phone density			0.386***	-0.0904**
			(0.050)	(0.045)
Exporter's road density			0.0837	0.200***
			(0.066)	(0.067)
Observations	3974	3974	3974	3974

*, **, *** indicate that the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

Table 7. Heckman regression, 2004 (low-income exporter sample)

Coefficient	Not including infrastructure		Including infrastructure	
	Logtrade	**Likelihood**	**Logtrade**	**Likelihood**
Exporter's GDP	1.089***	0.290***	0.971***	0.0824
	(0.12)	(0.11)	(0.13)	(0.13)
Importer's GDP	0.574***	0.137***	0.619***	0.180***
	(0.095)	(0.049)	(0.081)	(0.051)
Bilateral distance	-0.895***	-0.167	-1.050***	-0.215
	(0.27)	(0.14)	(0.23)	(0.15)
Distance of exporter from world	1.733	-1.496*	1.532	-2.221**
	(1.96)	(0.87)	(1.76)	(0.94)
Distance of importer from world	-0.361	-0.786**	-0.243	-0.775**
	(0.75)	(0.32)	(0.63)	(0.32)
Bilateral tariff	-0.0251	0.117	0.268	0.189
	(0.33)	(0.15)	(0.30)	(0.16)
Relative import protection	0.119	-0.0203	0.0565	-0.0274
	(0.19)	(0.087)	(0.16)	(0.089)
Relative export protection	-0.0560	-0.108	-0.339	-0.192
	(0.28)	(0.13)	(0.26)	(0.14)
Landlocked exporter	-0.0885	-0.00545	-1.097*	-0.885***
	(0.33)	(0.13)	(0.60)	(0.28)
Landlocked importer	-0.286	0.168	-0.340	0.185
	(0.43)	(0.19)	(0.36)	(0.19)
Contiguity	1.297	4.623	1.241	4.684
	(1.20)	(0)	(1.02)	(0)
Common language	0.577	0.276	0.460	0.416*
	(0.43)	(0.21)	(0.37)	(0.22)
Colonial relation	1.628	2.942	1.750	3.197
	(1.80)	(0)	(1.53)	(0)
African exporter's dummy	**-0.0545**	**-0.358***	**0.0609**	**-0.267**
	(0.41)	(0.20)	(0.35)	(0.21)
Historical frequency of trade		2.211***		2.061***
		(0.27)		(0.28)
Constant	-27.34***	-2.367	-16.20**	7.069*
	(5.57)	(3.18)	(6.99)	(4.11)
Exporter's phone density			-0.473*	-0.440***
			(0.25)	(0.12)
Exporter's road density			0.923***	0.342**
			(0.27)	(0.14)
Observations	1222	1222	1222	1222

*, **, *** indicate that the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

In the Heckman specifications, our exclusion variable is the historical frequency of positive trade, as previously discussed. From the probit regression of whether or not the trading partners trade in either of the three years over which the average level of trade is taken, the historical frequency is a very strong predictor of trading partners' propensity to trade.

The dummy variable for African exporters is negative and significant in the full sample, implying that if the comparator set of countries is the rest of the world, Africa is an underexporter. However, if the comparator is the rest of the world within the low-income group, then African low-income exporters do not underexport.[7] Note that given the global distribution of incomes, the low-income exporter sample includes a disproportionately large number of African countries. More importantly, in the presence of exporting-country infrastructure, the undertrading effect for Africa is lower. That undertrading effect without inclusion of infrastructure is robust to various specifications of the gravity model. The undertrading effect does get reduced with inclusion of infrastructure, and in some specifications it vanishes altogether.

To check for the robustness of the gravity model results on the underexporting by Africa, we ran log linear specifications (with zero trade excluded) and Tobit specifications, treating observed zero trade as a corner solution. Tables A.1 through A.5 in the appendix present the results from the log linear and Tobit specifications of the gravity model. The status of Africa as an undertrader in the global sample and not an undertrader in the low-income sample holds true in all these specifications. Although not presented, the results hold for a pooled sample for 2001 and 2004 and also for the inclusion of the importing-country infrastructure variables.

The results provide generally consistent evidence that trade-related infrastructure (transport and communication) is a significant determinant of trade flows and, accounting for infrastructure (in all the specifications), consistently reduces the size of the African export dummy variable. Thus, infrastructure (or its correlates, such as institutions) can be considered among the factors that account for at least part of undertrading by Africa. That conclusion follows from levels of trade-related infrastructure being on average lower in Africa than in the rest of the world and trade-facilitating infrastructure having a significant effect on trade flows.

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7 Although the results are not presented here, our analysis revealed that Africa is not an underimporter. Also not presented here are the results indicating that Africa appeared to be an underexporter when we controlled for importing-country infrastructure.

5. ROLE OF INFRASTRUCTURE IN AFRICAN TRADE

Having established that infrastructure is a potential factor in Africa's undertrading, we estimated its impact on trade using a partial linear specification of the gravity model, as given in equation (7a), which allows for all possible interactions across various types of infrastructure. We considered two infrastructure variables—road and phone-line density—because interactions between them are easy to conceive. The data on infrastructure for 2001 correspond to the averages of 1998 and 1999, and for 2004 they correspond to the averages of 2001 and 2002. The marginal impacts using the 2001 and 2004 samples separately were similar and are not reported here.

The impact of increments in phone-line and road density on trade for the countries in the sample with pooled data for 2001 and 2004 range from 0.0 to 0.88, respectively (for most countries the impact is evaluated at less than 0.4) and from 0.0 to 0.7. Although phone-line density increased drastically in all countries between 1998 and 2002, only small changes in road density (as a fraction of land area or of population) have occurred between those two periods. Thus, when we estimated the marginal impacts of phone lines for 2001 and 2004 separately, the impacts were significantly higher in 2004. We interpreted that result as possibly capturing the role of network effects. Network effects imply that starting from a higher base, the same percentage increase in phone-line density is much more effective because a large set of phone users already exists.

Among the set of African countries where the estimated marginal impacts of phone density on trade are statistically significant, the effects for several countries were also quantitatively significant. Thus, for countries like the Democratic Republic of the Congo, Chad, and Mauritius, a 1 percent increase in phone density is likely to increase exports by more than 0.35 percent. In several other African countries (e.g., Sierra Leone, Nigeria, Malawi and Tanzania), increases in exports greater than 0.1 percent from an increase in phone density exceeding 1 percent have been observed.

Broadly, African countries concentrated in a low-income distribution are similar in the estimated marginal impacts of phone density on trade with other low-income countries.

Similarly, we estimated statistically significant and quantitatively important impacts of road density on trade for several African countries. The highest estimated marginal impact of road density for African countries is nearly 0.7 percent in case of Sudan. Also, an impact on trade exceeding an impact on trade exceeding 0.1 percent from a 1 percent increase in road density has been observed in several African countries, including Guinea-Bissau, Mauritania, Gambia, and Madagascar. Figures A.1 through A.4 in the appendix present the estimated marginal impacts of phone and road infrastructure on trade (the top 20) for African and non-African countries. In the figures the estimated marginal impacts of phone-line and road density on trade flows are averaged across all bilateral trading pairs.

Some important points emerge from these marginal impacts. Among the set of African countries where the estimated marginal impacts of phone density on trade are significant, several countries are extremely poor—for example, Mali, Rwanda, and Burundi. Thus, for countries like the Democratic Republic of the Congo, Chad, and Mauritius, a 1 percent increase in phone density is likely to increase exports by more than 0.35 percent. In several other African countries, an increase in exports greater than 0.1 percent results from 1 percent increase in phone density has been observed—for example, in Sierra Leone, Nigeria, Malawi, and Tanzania.

Broadly, African countries concentrated in a low-income distribution are similar to other low-income countries in terms of the estimated marginal impacts of phone density on trade. Similarly, we estimated statistically significant and quantitatively important impacts on trade for several African countries in terms of road density. The highest estimated marginal impact of road density for African countries is nearly 0.7 percent in the case of Sudan. Also, an impact on trade greater than 0.1 percent from a 1 percent increase in road density has been observed in several African countries, such as Guinea-Bissau, Mauritania, Gambia, and Madagascar.

How do these estimated marginal impacts vary with country characteristics? Table 8 presents the average of the estimated marginal impacts across several country group characteristics. It includes the average for the world excluding Africa and for Africa alone. The average estimated marginal impact of road density in Africa is fairly constant across all groupings. Among low-income countries, the impacts were higher in Africa than elsewhere. The impacts varied significantly with the composition of exports. The impact of greater phone density unambiguously increases as the share of high technology or service exports increases in Africa.

Based on the cost of doing trade estimated by the World Bank (2007), Table 8 classifies the countries as those with low or high costs of trade (below or above the median in terms of document requirements, time to export, and costs to export, respectively). Importantly, in countries in Africa and elsewhere, wherever the existing costs of trade are higher, the marginal impacts of phone density are higher. Indeed, one cause of greater costs of trade or greater time taken to trade is lower levels of infrastructure.

Table 8. Marginal impacts and country characteristics

Characteristics	Average marginal impact of road by category		Average marginal impact of phone by category	
	Excluding Africa (rest of the world)	Africa only	Excluding Africa (rest of the world)	Africa only
All exporting countries	0.22	0.12	0.10	0.14
Landlocked exporter	0.11	0.32	0.12	0.16
Not landlocked exporter	0.13	0.18	0.15	0.09
Low-income exporter	0.26	0.28	0.06	0.11
Middle-income exporter	0.05	0.07	0.15	0.07
High-income exporter	0.05	-	0.30	-
Share of high-technology exports (greater than 25%)	0.13	0.22	0.13	0.11
Share of high-technology exports (less than 25%)	0.07	0.24	0.18	0.07
Ratio of service to merchandise exports (greater than median)	0.13	0.22	0.13	0.11
Ratio of service to merchandise exports (less than median)	0.07	0.07	0.24	0.20
Levels of other infrastructure and institutions (not incorporated in the model)*				
High aircraft departure	0.11	0.22	0.16	0.11
Low aircraft departure	0.11	0.25	0.09	0.10
High electricity	0.11	0.22	0.16	0.11
Low electricity	0.20	0.24	0.07	.0.07
High icrge index (high index for institutional quality)	0.11	0.23	0.15	0.70
Low icrge index (low index for institutional quality)	0.18	0.27	0.09	0.10
High Internet usage	0.16	0.21	0.11	0.11
Low internet usage	0.19	0.25	0.06	0.14
High document requirements	0.13	0.24	0.13	0.10
Low document requirements	0.07	0.12	0.22	0.07
High time to export	0.13	0.24	0.13	0.11
Low time to export	0.06	0.08	0.23	0.06
High exports cost	0.13	0.23	0.13	0.11
Low exports cost	0.08	0.18	0.20	0.07

Source: Author's calculations based on estimations from World Bank (2007).

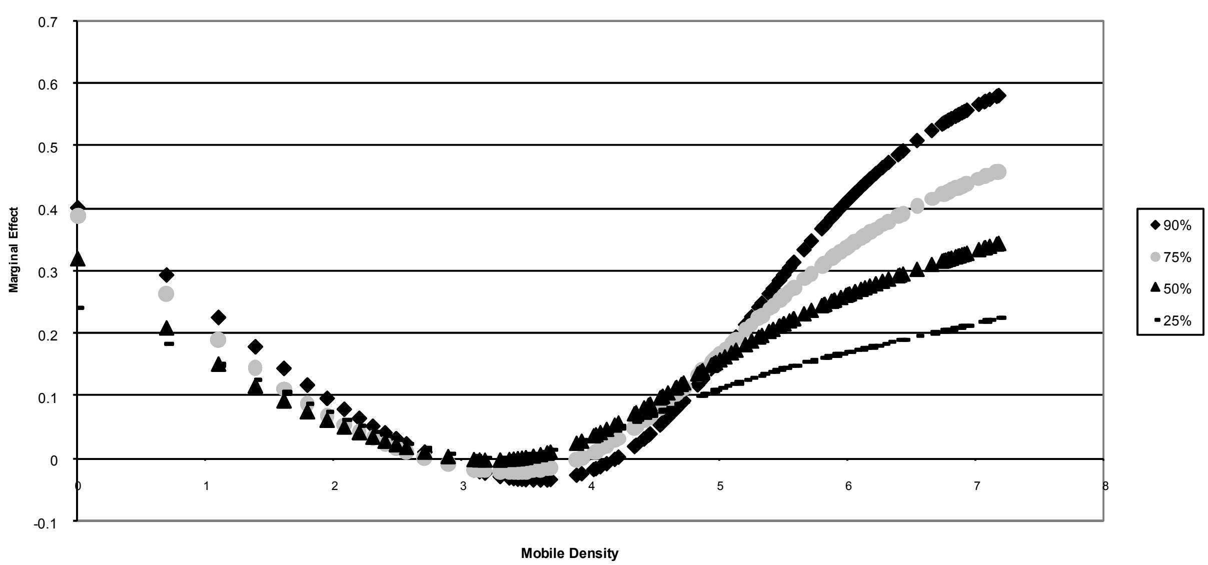
***** High = greater than median; low = smaller than median.

Given the specification of the partial linear gravity model, the marginal impact of either of the two infrastructures depends on the level of the other infrastructure, as previously discussed. The estimated marginal impact of roads or phone lines depends on the other infrastructure (e.g., the marginal impact of phone lines depends on the density of phone lines as well as the density of roads). Establishing complementarities across types of infrastructure is equivalent to addressing the following question: Independent of the country considered, is the marginal impact of one infrastructure on the average level of exports significantly higher when the level of the other infrastructure is higher?

Thus, for complementarity between phone and road connectivity, this counterfactual exercise required assigning same level of road density to all countries in the sample and obtaining different marginal impacts of phone lines for different phone-line densities. We call this a phone-line density plot (conditional on a given level of road density). A change in the level of road density could lead to a potential shift in the phone-line density plot. As explained in the previous section, local or global complementarity can be observed, depending on the resultant shift.

Figure 2 presents the results of a counterfactual exercise in which all countries in the sample are made to have the same road density. We consider four levels of road densities: the 25th, 50th, 75th , and 90th percentiles obtained from the empirical distribution of observed road density. In the figure, different lines are associated with the four different levels of road density. As expected, we witnessed local complementarity, which occurs when the log of phone-line density is between 1 and 4.5, when the phone-line density plot shifts upward. Complementarity is not observed in lower and upper extreme values for phone-line density.

Figure 2. Infrastructure complementarities



When the phone-line density is too low, it is expected that increasing road density will not affect the marginal impact of phone-line density because of the absence of a critical level of phone-line density. When the phone-line density is very high, the potential of phone-line penetration is already realized, and an increase in road density does not seem to have an effect. This idea of thresholds in the impact of infrastructure has increasingly been recognized through the use of threshold regressions in estimating the augmented production functions (see, e.g., Hurlin 2006). Our results support the idea of thresholds, albeit in terms of impact on trade and estimated in a way that allows for an unrestricted number of thresholds compared with the threshold regressions framework.

Even though it is natural to expect complementarity, a relationship like that has formally not been established in the trade literature. Note that this relationship does not correspond to a positive relationship between road density and the marginal impact of phone lines. Because different countries trade in different products and have different levels of determinants of trade, a monotonic relationship is difficult to predict across a cross section of exporting countries. Thus, complementarity implies that the higher the gain from investment in infrastructure (in terms of its impact on trade) for any country, the higher the level of infrastructure to which it is complementary.

6. CONCLUSIONS AND POLICY IMPLICATIONS

Our assessment of market access for Africa shows that on average Africa enjoys good access to foreign markets. However, there are significant variations within Africa with some low-income countries like Malawi facing worse market access relative to the rest of the world. Trade preferences can improve market access by lowering the duties faced on African exports. Based on the types of products on which preferences are granted and the countries that grant preferences to Africa, we found that the current true preference margin for Africa is negative. Thus, greater market access will help African exports, but again the effects are likely to be disparate across countries.

The evidence, however, suggests that even if preferences help raise the level of exports, Africa will likely continue to trade less than it should. The low quality of trade-related infrastructure in Africa implies that interventions that improve the level and quality of infrastructure can yield high returns in terms of mitigating the undertrading effect. However, the impact of infrastructure on trade exhibits significant complementarities. Thus, policy interventions that develop infrastructure in a piecemeal fashion in Africa are likely to yield much lower returns than those that develop infrastructure comprehensively.

Further, the significant impacts of infrastructure on trade have important policy implications in light of the aid-for-trade policy agenda that has surfaced in the Doha Round. Essentially, the principle behind the aid-for-trade agenda is the realization that observed low trading by countries with already good market access (in Africa and elsewhere but mainly in low-income countries) implies that market access is not the only reason for the declining trade performance of certain countries. Our finding that infrastructure has important and significant effects on trade basically supports the premise behind the aid-for-trade agenda.

Aid for trade has concurred with an increasing skepticism on the effectiveness of foreign aid (Rajan and Subramanian 2005; Easterly 2006). Trade and aid have often been viewed as substitutes for one another, but recently the aid-for-trade policy has gained prominence for its view that aid and trade are complements. Proponents of the policy argue that the capacity of developing countries to take advantage of any market access gains in the Doha Round is currently hampered by several supply-side bottlenecks and costs, administrative constraints, and poor institutions. Thus, aid for trade refers to additional aid devoted to tackling the trade-related constraints and adjustment costs in developing countries (Evenett 2005). Development of infrastructure in this regard is important for Africa and supports the aid-for-trade agenda.

In several African countries where good market access already exists, enhancing preferential access is likely to yield insignificant gains. In many of the same countries (e.g., Uganda), the high impacts of infrastructure imply that the gains in terms of enhanced trade might accrue through improvements in domestic factors, most noticeably in trade-related infrastructure.

APPENDIX

Table A.1. Average duties faced on exports

Country	Global	Agricultural	Industry	Primary (not agricultural)
Algeria	1.4%	12.7%	1.6%	1.1%
Angola	1.5%	6.4%	0.9%	1.5%
Benin	13.2%	23.7%	8.6%	4.7%
Botswana	1.9%	53.5%	0.9%	5.5%
Burkina Faso	11.0%	30.4%	5.8%	8.7%
Burundi	6.0%	11.2%	2.7%	3.3%
Cameroon	4.2%	10.7%	4.3%	1.3%
Central Africa Republic	1.6%	8.3%	1.4%	1.0%
Chad	1.3%	16.9%	2.0%	1.0%
Congo	2.9%	39.7%	2.7%	1.9%
Congo DR	1.2%	17.3%	0.7%	1.1%
Côte d'ivoire	5.7%	6.2%	5.7%	1.8%
Djibouti	11.0%	13.0%	9.8%	10.8%
Egypt	5.4%	21.5%	3.9%	1.4%
Equatorial Guinea	1.4%	2.2%	1.2%	1.4%
Eritrea	6.6%	14.6%	4.3%	2.4%
Ethiopia	9.1%	10.4%	3.6%	18.4%
Gabon	1.9%	24.6%	2.7%	1.4%
Ghana	4.8%	5.1%	4.8%	3.1%
Guinea-bissau	14.1%	22.9%	8.6%	1.6%
Kenya	12.5%	14.6%	10.6%	6.4%
Lesotho	1.3%	9.2%	1.3%	2.5%
Libya	1.3%	11.9%	3.4%	0.9%
Madagascar	3.5%	4.8%	2.4%	2.6%
Malawi	23.1%	27.4%	8.5%	6.1%
Mali	4.5%	9.0%	4.2%	3.3%
Mauritania	5.3%	9.7%	5.0%	0.7%
Mauritius	13.0%	40.7%	4.0%	3.2%
Morocco	5.0%	9.8%	4.0%	1.6%
Mozambique	5.1%	22.5%	1.8%	3.9%
Namibia	9.2%	20.9%	3.9%	1.8%
Niger	4.8%	17.8%	2.7%	0.5%
Nigeria	2.4%	4.5%	2.4%	2.4%
Rwanda	6.7%	17.6%	6.7%	2.4%
Senegal	10.1%	11.1%	10.4%	6.0%
Seychelles	5.3%	5.8%	4.7%	2.8%
South Africa	5.4%	17.6%	4.6%	1.5%
Sudan	4.4%	16.5%	5.0%	1.5%
Swaziland	19.0%	54.4%	8.8%	2.9%

Table A.1. Continued

Country	Global	Agricultural	Industry	Primary (not agricultural)
Tanzania	9.5%	18.9%	4.9%	2.1%
Togo	14.9%	17.1%	15.6%	3.3%
Tunisia	5.2%	19.4%	4.2%	0.9%
Uganda	8.6%	10.1%	6.7%	1.7%
Zambia	6.6%	24.5%	3.9%	3.0%
Zimbabwe	11.3%	23.7%	5.0%	4.8%
World	4.5%	16.0%	3.7%	1.5%
LDC	4.7%	15.3%	4.3%	2.0%
MIC	5.1%	20.0%	4.6%	1.5%
OECD	4.1%	14.0%	3.3%	1.3%
Africa	4.2%	15.2%	3.9%	1.6%
America	5.3%	18.5%	3.7%	1.2%
Asia	5.1%	19.3%	4.9%	1.6%
Europe	3.6%	12.1%	2.9%	1.2%
Pacific	10.6%	32.1%	4.3%	2.5%

Source: MAcMap HS6-2004 and author's calculation.

Table A.2. Log linear specification of the gravity model, 2001

Coefficient	Full sample		Low-income exporter sample	
	Logtrade (not including infrastructure)	Logtrade (including infrastructure)	Logtrade (not including infrastructure)	Logtrade (including infrastructure)
Exporter's GDP	1.118***	1.085***	1.059***	1.127***
	(0.010)	(0.012)	(0.040)	(0.042)
Importer's GDP	0.962***	0.963***	0.887***	0.889***
	(0.012)	(0.012)	(0.032)	(0.031)
Bilateral distance	-1.430***	-1.429***	-1.244***	-1.321***
	(0.035)	(0.035)	(0.12)	(0.11)
Distance of exporter from	0.604***	0.713***	1.658***	1.448**
	(0.12)	(0.12)	(0.63)	(0.62)
Distance of importer from	0.476***	0.472***	-0.458	-0.401
	(0.12)	(0.12)	(0.29)	(0.28)
Bilateral tariff	0.0953*	0.112**	0.511***	0.603***
	(0.050)	(0.050)	(0.11)	(0.12)
Relative import protection	0.0467	0.0374	-0.123	-0.179**
	(0.033)	(0.032)	(0.091)	(0.090)
Relative export protection	-0.146***	-0.163***	-0.464***	-0.541***
	(0.042)	(0.042)	(0.083)	(0.085)
NTBs of importer	-0.0716***	-0.0728***	-0.0633	-0.0807
	(0.022)	(0.022)	(0.058)	(0.056)
Landlocked exporter	-0.0469	-0.0550	-0.0889	-0.142
	(0.061)	(0.061)	(0.12)	(0.13)
Landlocked importer	-0.500***	-0.499***	0.118	0.0454
	(0.062)	(0.062)	(0.15)	(0.15)
Contiguity	1.021***	1.069***	1.504***	1.468***
	(0.13)	(0.13)	(0.39)	(0.35)
Common language	0.747***	0.727***	0.990***	0.838***
	(0.066)	(0.066)	(0.15)	(0.15)
Colonial relation	0.588***	0.609***	2.345**	2.732***
	(0.14)	(0.14)	(1.08)	(0.88)
African exporter's dummy	-0.285***	-0.0394	0.121	0.439***
	(0.067)	(0.075)	(0.16)	(0.16)
Exporter's phone density		0.0763***		0.162
		(0.016)		(0.10)
Exporter's road density		0.0663***		0.545***
		(0.025)		(0.072)
Constant	-32.17***	-31.51***	-30.28***	-27.52***
	(0.55)	(0.57)	(1.99)	(2.13)
Observations	6998	6998	1260	1260
R-squared	0.74	0.74	0.54	0.57

*, **, *** indicate that the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

Table A.3. Tobit model, 2001

Coefficient	Full sample		Low-income exporter sample	
	Not including infrastructure	**Including infrastructure**	**Not including infrastructure)**	**Including infrastructure**
Exporter's GDP	1.460***	1.386***	1.688***	1.810***
	(0.014)	(0.017)	(0.068)	(0.070)
Importer's GDP	1.244***	1.242***	1.520***	1.508***
	(0.016)	(0.016)	(0.049)	(0.048)
Bilateral distance	-1.817***	-1.809***	-1.995***	-2.066***
	(0.048)	(0.048)	(0.17)	(0.16)
Distance of exporter from world	0.286*	0.492***	2.371***	2.517***
	(0.16)	(0.16)	(0.88)	(0.88)
Distance of importer from world	0.441***	0.444***	-1.441***	-1.343***
	(0.15)	(0.15)	(0.40)	(0.39)
Bilateral tariff	0.267***	0.294***	0.891***	0.972***
	(0.061)	(0.060)	(0.17)	(0.17)
Relative import protection	0.113**	0.0938**	-0.190	-0.279**
	(0.046)	(0.046)	(0.14)	(0.14)
Relative export protection	-0.343***	-0.367***	-0.790***	-0.844***
	(0.047)	(0.047)	(0.12)	(0.12)
NTBs of importer	-0.122***	-0.125***	-0.154*	-0.172**
	(0.030)	(0.029)	(0.085)	(0.083)
Landlocked exporter	-0.299***	-0.293***	-0.499***	-0.475**
	(0.076)	(0.076)	(0.17)	(0.19)
Landlocked importer	-0.766***	-0.765***	-0.416*	-0.467**
	(0.079)	(0.079)	(0.24)	(0.23)
Contiguity	0.989***	1.098***	1.787***	1.795***
	(0.20)	(0.20)	(0.58)	(0.57)
Common language	0.983***	0.936***	1.341***	1.156***
	(0.087)	(0.086)	(0.23)	(0.23)
Colonial relation	0.0936	0.139	2.452	3.030
	(0.27)	(0.26)	(1.90)	(1.86)
African exporter's dummy	**-0.321*****	**0.168***	**0.894*****	**1.275*****
	(0.075)	(0.088)	(0.22)	(0.22)
Exporter's phone density		0.171***		0.676***
		(0.021)		(0.16)
Exporter's road density		0.110***		0.542***
		(0.033)		(0.11)
Constant	-44.73***	-43.41***	-55.15***	-55.74***
	(0.72)	(0.73)	(2.90)	(3.08)
Observations	8713	8713	1914	1914

*, **, *** indicate that the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

Table A.4. Log linear specification, 2004

Coefficient	Full sample		Low-income exporter sample	
	Logtrade (not including infrastructure)	**Logtrade (including infrastructure)**	**Logtrade (not including infrastructure)**	**Logtrade (including infrastructure)**
Exporter's GDP	1.208***	1.191***	1.283***	1.283***
	(0.017)	(0.017)	(0.069)	(0.069)
Importer's GDP	0.870***	0.874***	0.794***	0.794***
	(0.021)	(0.021)	(0.059)	(0.059)
Bilateral distance	-1.319***	-1.314***	-1.109***	-1.109***
	(0.056)	(0.056)	(0.19)	(0.19)
Distance of exporter from	1.059***	1.174***	1.224	1.224
	(0.19)	(0.19)	(1.47)	(1.47)
Distance of importer from	-0.594***	-0.613***	-1.508***	-1.508***
	(0.19)	(0.19)	(0.54)	(0.54)
Bilateral tariff	-0.490***	-0.447***	0.124	0.124
	(0.086)	(0.087)	(0.26)	(0.26)
Relative import protection	0.0481	0.0428	-0.00797	-0.00797
	(0.053)	(0.053)	(0.19)	(0.19)
Relative export protection	0.493***	0.448***	-0.0812	-0.0812
	(0.071)	(0.072)	(0.20)	(0.20)
NTBs of importer	-0.0560	-0.0620*	-0.118	-0.118
	(0.037)	(0.037)	(0.12)	(0.12)
Landlocked exporter	-0.0877	0.0964	-0.0299	-0.0299
	(0.098)	(0.100)	(0.27)	(0.27)
Landlocked importer	-0.580***	-0.588***	-0.240	-0.240
	(0.11)	(0.11)	(0.35)	(0.35)
Contiguity	1.011***	1.040***	0.803	0.803
	(0.22)	(0.22)	(0.77)	(0.77)
Common language	0.814***	0.772***	1.096***	1.096***
	(0.11)	(0.11)	(0.32)	(0.32)
Colonial relation	-0.416	-0.428	0	0
	(0.30)	(0.31)	(0)	(0)
African exporter's dummy	**-0.361*****	**-0.139**	**-0.0832**	**-0.0832**
	(0.11)	(0.12)	(0.29)	(0.29)
Exporter's phone density		0.157***		
		(0.030)		
Exporter's road density		-0.0694*		
		(0.039)		
Constant	-33.41***	-34.44***	-32.45***	-32.45***
	(0.83)	(0.88)	(4.05)	(4.05)
Observations	3826	3826	661	661
R-squared	0.68	0.68	0.47	0.47

*, **, *** indicate that the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

Table A.5. Tobit regression, 2004

Coefficient	Full sample		Low-income exporter sample	
	Not including infrastructure	**Including infrastructure**	**Not including infrastructure**	**Including infrastructure**
Exporter's GDP	1.283***	1.266***	1.394***	0.885***
	(0.020)	(0.021)	(0.085)	(0.11)
Importer's GDP	0.953***	0.956***	0.997***	1.007***
	(0.024)	(0.024)	(0.069)	(0.065)
Bilateral distance	-1.409***	-1.404***	-1.412***	-1.523***
	(0.060)	(0.060)	(0.20)	(0.20)
Distance of exporter from	0.968***	1.111***	0.807	-0.983
	(0.22)	(0.22)	(1.52)	(1.51)
Distance of importer from	-0.842***	-0.863***	-2.621***	-2.303***
	(0.19)	(0.19)	(0.54)	(0.51)
Bilateral tariff	-0.407***	-0.367***	0.484*	1.123***
	(0.090)	(0.091)	(0.29)	(0.28)
Relative import protection	-0.0180	-0.0247	-0.286	-0.458**
	(0.060)	(0.060)	(0.21)	(0.20)
Relative export protection	0.512***	0.471***	-0.146	-0.727***
	(0.071)	(0.071)	(0.21)	(0.22)
NTBs of importer	-0.107***	-0.112***	-0.272**	-0.306***
	(0.040)	(0.040)	(0.12)	(0.12)
Landlocked exporter	-0.160	0.00674	-0.333	-3.245***
	(0.097)	(0.10)	(0.25)	(0.48)
Landlocked importer	-0.673***	-0.677***	-0.512	-0.467
	(0.12)	(0.12)	(0.39)	(0.37)
Contiguity	1.102***	1.122***	0.666	0.570
	(0.23)	(0.23)	(0.85)	(0.81)
Common language	0.875***	0.837***	1.040***	0.944***
	(0.12)	(0.12)	(0.34)	(0.33)
Colonial relation	-0.646	-0.655		
	(0.49)	(0.49)		
African exporter's dummy	**-0.503*** **	**-0.284** **	**-0.321**	**0.0146**
	(0.099)	(0.11)	(0.31)	(0.30)
Exporter's phone density		0.139***		-1.401***
		(0.034)		(0.19)
Constant	-35.84***	-36.65***	-33.76***	-0.386
	(0.95)	(0.99)	(4.16)	(5.89)
Exporter's road density		-0.0343		1.867***
		(0.044)		(0.22)
Observations	3974	3974	725	725

*, **, *** indicate that the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

Figure A.1. Marginal impact of phone density, top-20 African countries

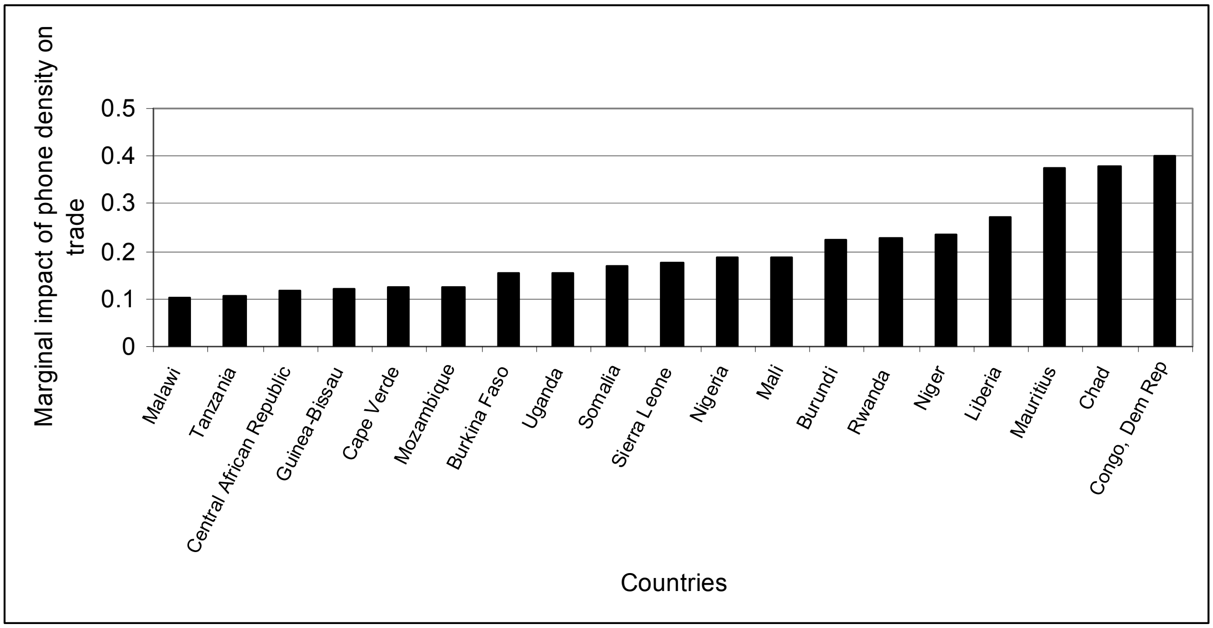


Figure A.2. Marginal impact of phone density, top-20 non-African countries

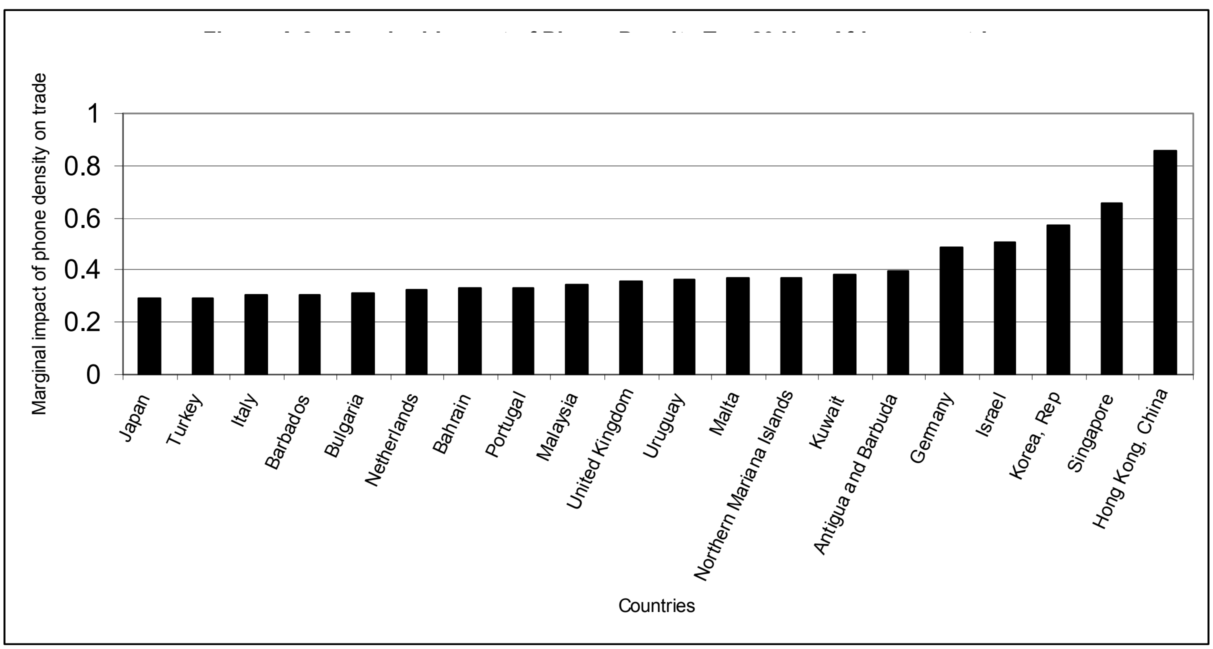


Figure A.3. Marginal impact of road density, top-20 African countries

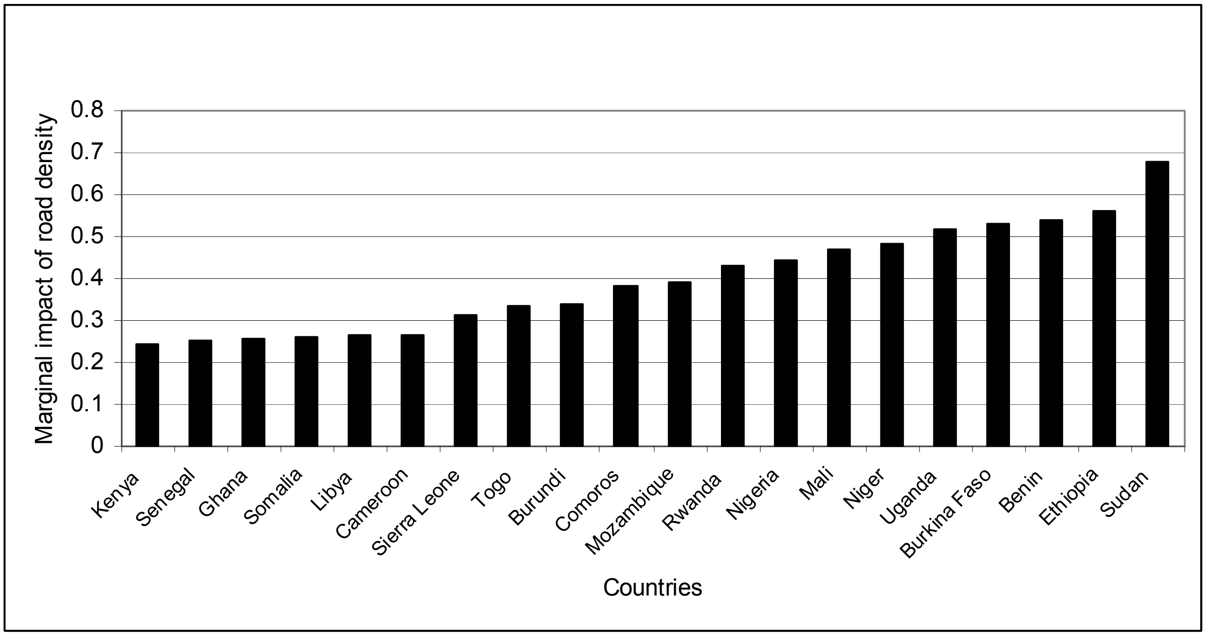
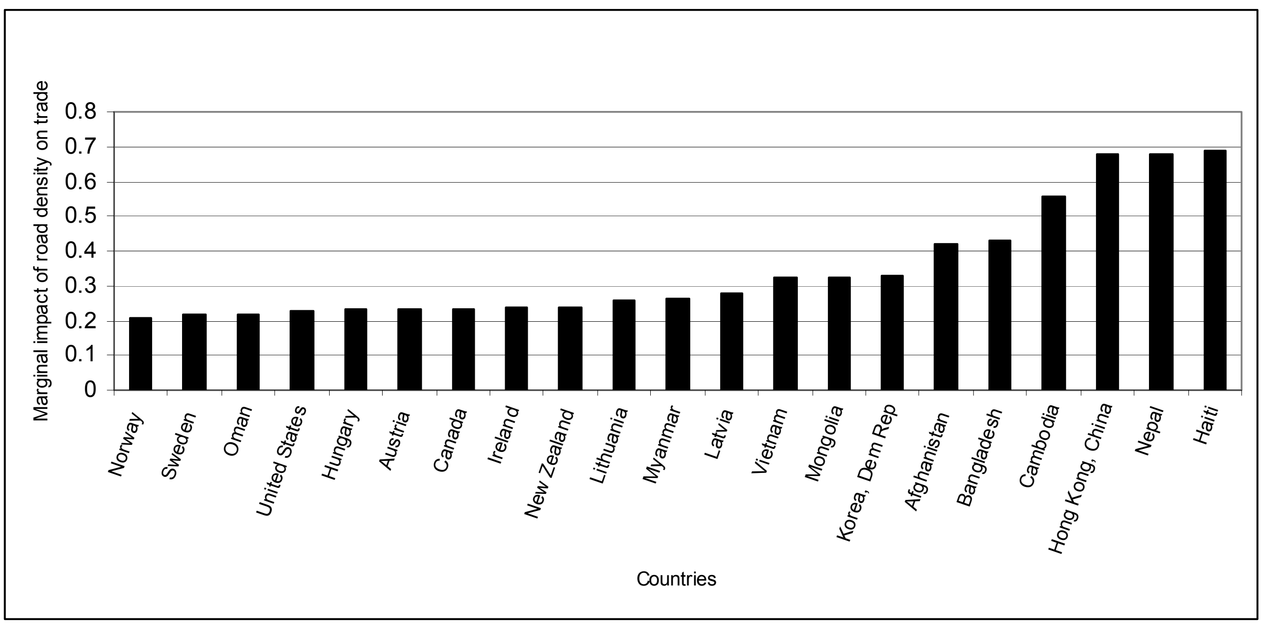


Figure A.4. Marginal impact of road density on trade, top-20 non-African countries



REFERENCES

Anderson, J., and E. van Wincoop. 2003. Gravity with gravitas: A solution to the border puzzle. *American Economic Review* 93: 170–192.

Bouët, A., Y. Decreux, L. Fontagné, S. Jean, and D. Laborde. 2008. Assessing applied protection across the world. Review of International Economics, forthcoming.

Bouët, A., L Fontagné, and S. Jean. 2005. Is erosion of preferences a serious concern? In *Agricultural trade reform and the Doha Development Agenda*, ed. K. Anderson and W. Martin. Washington, DC: World Bank.

Bougheas, S., P.O. Demetriades, and E.L.W. Morgenroth. 1999. Infrastructure, transport costs and trade. *Journal of International Economics* 47, no. 1: 169–189.

Carroll, R.J., J. Fan, I. Gijbels, and M.P. Wand. 1997. Generalized partially linear single index model. *Journal of the American Statistical Association* 92: 477–489.

Coe, D.T., and A.W. Hoffmaister. 1998. *North–south trade: Is Africa unusual?* IMF Working Paper No. 98/94, International Monetary Fund, Washington, DC. http://www.imf.org/external/pubs/ft/wp/wp9894.pdf.

Easterly, W. 2006. Planners versus searchers in foreign aid. *Asian Development Review* 23, no. 2: 1–35. http://www.nyu.edu/fas/institute/dri/Easterly/File/Planners_vs_Searchers_ADB.pdf.

Evenett, S. 2005. From "trade versus aid" to "aid for trade." *WTO News* 13. http://www.siaw.unisg.ch/org/siaw/web.nsf/SysWebRessources/wton13epdf/$FILE/wtonews13e.pdf.

Fan, J., C. Zhang, and J. Zhang. 2001. Generalized likelihood ratio statistics and Wilks phenomenon. *Annals of Statistics* 29: 153–193.

Foroutan, F., and L. Pritchett. 1993. Intra-Sub-Saharan trade: Is it too little? *Journal of African Economies* 2, no. 1: 74–105.

Fontagné, L., M. Pajot, and J.-M. Pasteels. 2002. Potentiels de commerce entre économies hétérogènes : un petit mode d'emploi des modèles de gravité. *Economie et Prévision* 152–153: 115–139.

Francois, J.F., and M. Manchin. 2007. Institutions, infrastructure, and trade. CEPR Discussion Paper No. 6068, Centre for Economic Policy Research, London.

Gaulier, G., S. Zignago, D. Sondjo, A.A. Sissoko, and R. Paillacar. Forthcoming (July). BACI: A world database of international trade at the product-level. The 1995–2004 version. CEPII Working Paper, Centre d'Etudes Prospectives et d'Informations Internationales, Paris.

Heckman, J.J. 1979. Sample selection bias as a specification error. *Econometrica* 47, no. 1: 153–161.

Helpman, E., M. Melitz, and Y. Rubinstein. 2007. Estimating trade flows: Trading partners and trading volumes. Mimeo, Harvard University, Cambridge, MA.

Hurlin, C. 2006. *Network effects of the productivity of infrastructure in developing countries*. Policy Research Working Paper No. 3808, World Bank, Washington, DC.

Kee, H.L., A. Nicita, and M. Olarreaga. 2006. *Estimating trade restrictiveness indices*. Policy Research Working Paper No. 3840, World Bank, Washington, DC.

Linders, G-J.M., and H.L.F. de Groot. 2006. *Estimation of the gravity equation in presence of zero flow*. Discussion Paper No. 2006-72/3, Tinbergen Institute, Amsterdam.

Rajan, R., and A. Subramanian. 2005. *Aid and growth: What does cross-country evidence really show?* IMF Working Paper No. 127, International Monetary Fund, Washington, DC.

Robinson, P.M. 1988. Root-N-consistent semiparametric regression. *Econometrica* 56, no. 4: 931–954.

Rodrik, D. 1998. *Trade policy and economic performance in Sub-Saharan Africa.* NBER Working Paper No. 6562. National Bureau of Economic Research. Cambridge, MA.

Sachs, J.D., and A.M. Warner. 1997. Sources of slow growth in African economies. *Journal of African Economies* 6, no. 3: 335–376.

Subramanian, A., and N. Tamirisa. 2001. Africa's trade revisited. IMF Working Paper No. 01/33, International Monetary Fund, Washington, DC.

Subramanian, A., and S-J. Wei. 2007. The WTO promotes trade, strongly but unevenly. *Journal of International Economics*, 172, no. 1: 151–175.

World Bank. 2000. Can Africa claim the 21st century? Washington, DC.

———. 2005. World development indicators. http://www.worldbank.org/data/.

———. 2007. *Doing business 2008*. Doing Business Project, International Bank for Reconstruction and Development/World Bank. http://www.doingbusiness.org//documents/FullReport/2008/DB08_Full_Report.pdf.

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