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Does Africa trade less than it should and why?

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Abstract

Africa's share in world exports has declined sharply over time. This raises the question whether the observed pattern of exports from Africa is consistent with the predicted or expected level of trade. This paper addresses the question whether or not Africa is an under-trading continent. We answer this question using a much improved dataset for obtaining predicted trade and by employing methods that correct for bias in estimates of under-trading. Our results indicate that globally Africa is an under-exporter in our preferred Heckman specification. This result is robust to addition of different controls and application of different variants of the gravity model of trade. We further ask the question what could explain Africa's under-trading. We find that accounting for transport and communication infrastructure reduces the under-trading effect for Africa and in some specifications of the gravity model, the under-trading effect vanishes altogether. In order to assess the impact of infrastructure on trade, we employ a semi parametric variant of the gravity model. This model allows for unknown nonlinear impact of infrastructure on trade and also complementarity among several infrastructure variables. Results from the semi-parametric model provide evidence for significant non-linear impacts of infrastructure where the effects for a large number of African countries are significant and compare favorably with marginal effects of infrastructure in countries in other continents being in comparable income brackets. This model also finds evidence for complementarity across transport and communication infrastructure implying that much greater impacts will be likely if the infrastructure are developed jointly rather than in isolation.

Does Africa trade less than it should and why?

1. Introduction

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

Gravity model of trade that explains 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 the observed trade quite well. The difference between actual and predicted trade classifies countries as under-trading, over trading or normal trading depending upon whether the difference is negative, positive or statistically not different from zero (see Subramanian and Tamirisa, 2001). Since, under-trading is defined relative to the predicted trade, it is model and data specific.

However, the issue of under-trading by Africa has remained highly debated in the literature with results depending upon the region considered, the time 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. 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 find support for under-trading by Africa.

On the other side, there exists a relatively well developed literature that argues Africa has been trading in line with predicted trade or even has been over-trading. In a pioneering study, Foroutan and Pritchett (1993) showed that there was no evidence that intra-sub-Saharan Africa (SSA) trade flows were differentially low either because of policy or infrastructural weakness and observed trade tallied with levels of predicted trade. 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 over-traded compared with developing countries in other regions. However, Coe and Hoffmaister (1998) do 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 (1998) for not controlling for a key variable in their analysis — the preferential trading arrangement between EU and Africa under the Lome Convention.

In this paper we revisit the question whether or not Africa is an under-trading continent. We answer this question using a much improved dataset for obtaining predicted trade and by employing methods that correct for bias in estimates of under-trading. 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 cited above focuses on exploring whether or not Africa under-trades but does not explain rigorously the reasons for under-trading (if obtained). We attempt to answer this question: what can potentially explain Africa's under-trading, a question that has not been addressed in the literature formally.

To study the issue of under-trading, we use the MacMAP dataset due to Bouet et al (2007) for obtaining the predicted levels of trade. The MAcMAP database on trade protection covers a more extensive set of trade protection (relative to the other existing measures) measures viz. ad valorem equivalent (AVE) of specific tariffs, AVE of tariff rate quotas and AVE of anti dumping duties and it also allows to capture country specific levels of market access by accounting for all regional agreements and preferential schemes.

We find that not only the levels but also the distribution of protection across countries varies significantly with the breadth of the measures. This points to a 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 find that within Africa, market access varies widely across countries even being part of the same preferential arrangement mainly owing to the composition of exports. Thus, use of membership dummies to capture the effect of preferential trading arrangements again amounts to measurement error in market access variables. The measure of trade protection in this paper minimizes these two measurement errors.

In addressing the question, whether or not Africa under-trades, we use the Heckman sample selection method to account for zero trade flows. We find evidence that globally Africa is an under-exporter but not an under-importer. We further test for robustness of this result using the conventionally employed variants of gravity model, viz. the log linear and Tobit specifications. More importantly, under-exporting 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 potentially explain under-trading by Africa in a global sample. Trade related infrastructure is one such factor which is likely to be a significant determinant of trade costs and hence exports. We find that accounting for transport and communication infrastructure in exactly the same sample of countries where Africa emerges as an under-trader reduce the under-trading effect. In fact in some specifications under-trading 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 (2006) estimate the effect of infrastructure on trade by including infrastructure linearly in a gravity model. Quantifying the true impact of infrastructure on trade however is difficult mainly because of the interactive nature of different types of infrastructure. Thus, the impact of greater telephone connectivity depends upon the supporting road infrastructure and vice versa. Most importantly, the precise way this dependence among infrastructure types occurs is unknown and there does not exist any a priori theoretical basis for presuming the functional forms for such interactions. In this paper, we thus employ a semi parametric variant of the gravity model that allows for unknown nonlinear impact of infrastructure

on trade and complementarity among several infrastructure variables. For Africa, we find that for a good number of African countries, the marginal impacts of infrastructure on trade are significant and lie in the range of estimated impacts for most non-African developing countries. Our semi-parametric model indicates evidence for complementarity across different 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 as follows. 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. Section 5 discusses the semi parametric model and the results on the impact of infrastructure on trade for Africa. Section 6 concludes.

2. Methodology

We adopt Fontagné, Pajot and Pasteels (2005) (here on FPP 2005) model augmented for the role of infrastructure in determining trade costs. In FPP (2005) model, all goods are differentiated by the place of origin and each region produces only one good. The supply of each good is fixed. Consumers have identical and homothetic preferences represented by a CES utility function. Let c_{ij} be the consumption of good produced in country i by agents in country j. The utility functions of the agents in country j are denoted as U_j.

The agents in country j maximize U_j subject to the budget constraint, i.e.

Max:

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

subject to the budget constraint:

$$\sum_i p_{ij} c_{ij} = y_j. \qquad (2)$$

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:

$$p_{ij} = p_i \tau_{ij}.$$

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 country i is: $y_i = p_i Q_i$. Let s_i be the share of country i in world income y^W.

After maximizing (1) subject to (2) and few transformations, we get:

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

where,

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

is a CES index of the trade costs in exports from country 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), the demand capacity of j (j's income - y_j) and negatively related to trade costs where trade costs include the trade costs borne by i in exporting to all other destinations. Thus, the trade costs include multilateral trade resistance terms as in Anderson and van Wincoop (2003). This concept implies that in a gravity model not only are bilateral trade costs important but also the trade costs of these countries with rest of the world as well as within country trading costs. The practice that has been common to proxy for multilateral resistance is to include exporter and importer fixed effects in the regressions (see Subramanian and Wei 2006 for example). Since we are interested in the identification of the effect of Africa dummy which does not vary over time, we use cross-sectional gravity regressions (for 2001 and 2004 sample separately and pooled). Even if we were focused on identifying the effect of infrastructure, given the two close time periods, there is little variation over time to exploit. Hence, coefficients of infrastructure variables (which are nearly time invariant) cannot be identified in presence of exporter fixed effects.

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

The bilateral trade costs in the presence of infrastructure can be given as:

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

In equation (5), t_{ij} is the bilateral import duty applied by country j on exports from i.[1] Transportation costs are assumed to increase with geographic distance between trading countries d_{ij} and vary negatively with the level of infrastructure in exporting country.[2] In the simplest formulation where infrastructure is included linearly, the function m is $m(I_i) = \dfrac{1}{I_i}$ (where I_i denotes infrastructure in the exporting country) and transport costs are specified as $\tau_{ij} = \dfrac{(1 + t_{ij}) d_{ij}^{\rho}}{I_i}$.

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

The basic linear specification of the gravity equation is given below as:

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[2] Ideally there could be importer's infrastructure as well. We do include importer infrastructure in some specification and the results are identical. The results reported are with exporter infrastructure only mainly because in low income sample the number of observations shrinks considerably while including importing country infrastructure.

$$\ln(X_{ij}) = \beta_0 + \beta_1 \ln(Y_i) + \beta_2 \ln(Y_j) + \gamma \ln(d_{ij}) + \rho \ln(t_{ij}) + \sum_i \theta_i \mu_{ij}$$

$$+ \delta A_{i/j} + \sum_s \eta_s T_i + \sum_{s'} \eta'_{s'} T_j + \sum_i \lambda_i \ln(I_i) + \varepsilon_{ij} \qquad (6)$$

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 is a vector containing s and s' multilateral trade resistance terms for the exporters and importers. μ_{ij} is a vector of variables that capture the relationships that can matter for trade, like sharing of a common border among others. The dummy A_i and A_j capture respectively whether the exporter or the importer in a bilateral trading pair falls in Africa.

We also estimate other forms of equation (6) to account for zero trade flows. Some studies employ a Tobit estimator to examine bilateral zeros (for example Subramanian and Tamirisa 2001). Other papers use sample selection correction to account for zero trade flows. Francois and Manchin (2006) employ the Heckman method to control for sample selection but their framework does not include an exclusion variable for likelihood of trade.[3] 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 very restricted set of countries. The strength of the exclusion variable in Helpman et al (2007) comes from its theoretical underpinning.[4]

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 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 is thus the Heckman specification where we treat zero trade to imply that the countries that have a positive trade comprise a selected sample. The sample selection model allows accounting 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 (for example geographical distance). It is thus challenging to select variables that are highly correlated with country's propensity to export and not correlated with the actual levels of exports. We use the historical frequency of positive trade between the two countries as the exclusion variable. The premise is that higher the frequency of positive trade in the past, greater is the likelihood of two countries having a non-zero trade flow in the current period. Since our trade flow variable for the current time period is an average over three years, the relationship between historical frequency and likelihood of current trade is likely to be more systematic. Subsequently, variants of equations (6) are estimated on a truncated sample

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[3] Helpman et al (2007) applying the Heckman model for sample selection use measures of fixed costs of entry as the exclusion variable which comes from the theoretical model that they construct.

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

which includes only the low income exporter countries and low income importer countries respectively.

In equation (6), infrastructure enters the gravity model linearly as in Bougeas et al (1999) and Francois and Manchin(2006). Without any prior for the nature of linkage between trade and infrastructure, the semi parametric framework that we employ for estimating the impact of infrastructure on trade can be really meaningful. In the partial linear model, we assume that the conditional mean has a linear parametric component (the standard gravity model variables) and a non-parametric component (i.e. a function of the levels of infrastructure).

The partial linear model is thus specified as:

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

The partial linear model that controls for sample selection is given as:

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

where IM_i denotes the inverse mills ratio from the first stage of the Heckman regression and where $\varepsilon_{ij} \square iid(0, \sigma^2)$ and $I = (I_{i1}, I_{i2})'$. The two infrastructure variables that we use in the partial linear model are mobile 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

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

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

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

Note that $m_j^{(1)}(\tilde{I}_1, \tilde{I}_2)$ is the marginal effect of the jth 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.[5]

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[5] 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).

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 this case, we have local complementarity which is more plausible. Thus, it is possible that when the road density is too low, then increasing road density may not increase the marginal impact of mobiles on trade but beyond a critical level, increases in road density positively affect the marginal impact of mobile density.[6]

2. Data and descriptive statistics

The bilateral export data are obtained from the dataset BACI[7] compiled by Centre d' Etudes Prospectives et d' Informations Internationales (CEPII). For the 2001 and 2004 trade flows, we average the data over three time periods (1998-2001) and (2002-2004) respectively 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 dataset. The distance measure here is the bilateral distances between the biggest cities of the two trading partners weighted by the share of the city in the country's population.

Our GDP data are obtained from the World Development Indicators of the World Bank. The information on the transport and communication infrastructure variables is also obtained from the World Development Indicators. We use the transport variable road density defined as the total road length as a proportion of land area and as a proportion of the total population respectively. Communication infrastructure is measured in terms of the phone density in the country viz. mobile and fixed lines per one thousand people. For 2001 sample we use the average of the infrastructure data for year 1998 to 2001 and for 2004, we use the average of the infrastructure data for years 2002 to 2004.

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

We use the data on trade protection from the MAcMap database for the two time periods viz. 2001 and 2004. We capture the country specific market access by using the actual bilateral tariffs (taking into account the effect of all preferences). This is especially important since our time period of analysis (2001 and 2004) includes the effect of two large scale preferential arrangements for Africa, Everything but Arms Initiative (EBA) of

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[6] Specifying the partial linear model as $P_{ij} = S_{ij}'\beta + m(Z_i) + \varepsilon_{ij}$, we can estimate the parameters and the non-parametric 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).

[7] See Gaulier et al. 2007.

EU and the African Growth and Opportunity Act (AGOA) of the United States in the second time period.

The import duty 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) ad valorem equivalent tariffs from information on either bound Most Favored Nation (MFN) regime, or Applied Most Favored Nation regime, or preferential regime granted by the importer to the exporter on this 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 average duty applied to a country's imports, or average duty faced by a country's exports, or world average duty on a specific product, or any combination thereof. The duty utilized can either be the preferential duty, or the MFN applied duty, or the bound duty. The MacMAP weighting scheme aims to avoid the endogeneity bias (following the use of country's own imports as weights) that is common in this kind of measurements, by using trade structure of a reference group of countries that have level of GDP per capita close to the importers as weights (for more details see Bouet et al., 2008).

The ad valorem equivalent of the non-tariff barriers is from Kee et al (2006) that is available only at a multilateral level. Including the ad valorem equivalents of NTBs reduces our sample size significantly thus we run specification with and without NTB measures (only the results with NTBs included have been reported in the paper).

The summary statistics for the data are reported in Table 1 below.[8] Comparison is made between a sample containing non-African exporters and African exporters. Few important points emerge: on average, African exporters are farther from the economic centers of the world, including in a group of low income exporters. Note that relatively developed countries viz. the proportion of African exporters who are landlocked is much higher relative to the same proportion among the non African exporters. Africa enjoys greater market access relative to the rest of the world in terms of both tariff and non-tariff barriers.

Table 2 presents summary comparisons across different types of infrastructure between Africa and the rest of the world globally. Clearly, the level of infrastructure in both 2001 and 2004 sample is lower for Africa. Road infrastructure in particular is slow to change and one does not expect significant changes between the two time periods. However, there has been a quantum jump in the phone infrastructure especially the mobile infrastructure and it has risen significantly across all countries including the African countries.

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[8] Same descriptive statistics for the low income exporter sample can be requested to authors.

Table 1: Summary of data (full sample)

Variable	Mean (2001) for non-African countries	Std. Dev. (2001) for non-African countries	Mean for African countries 2001	Std. Dev. for African countries 2001	Mean (2004) for non-African countries	Std. Dev. (2004) for non-African countries	Mean for African countries 2004	Std. Dev. for African countries 2004
	Number of observations -6625		Number of observations - 1965		Number of observations -3245		Number of observations - 1080	
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	Mean (2001) for non-African countries	Std. Dev. (2001) for non-African countries	Mean for African exporters 2001	Std deviation for African exporters 2001	Mean (2004) for non-African countries	Std. Dev. (2004) for non-African countries	Mean for African exporters 2004	Std deviation for African exporters 2004
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
Mobile per thousand people	79.75	116.65	4.10	11.42	317.02	291.33	31.62	54.91
Main line per thousand 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 distribution of protection based on the breadth of included measures of protection. Figures 1 compares the distribution of protection faced by 207 countries in 2001 in the full sample when only ad valorem tariffs are included and when specific tariffs are also included. As discussed above, the distribution of applied protection changes significantly depending upon the breadth of included measures of protection, thus pointing to potential measurement errors when using incomplete data.

Figure 1: Distribution of protection faced by exports based on breadth of measures (2001)
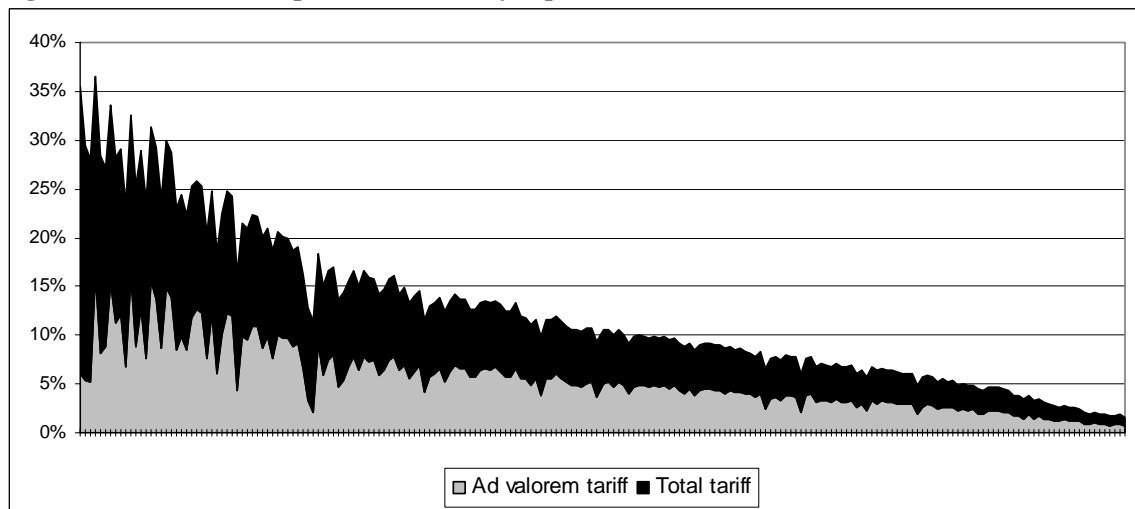
Source: MacMAP 2001

From calculation of average duties faced by exports of different continents (results can be requested from the authors), we find that Africa's access to foreign markets is on average better than America, Asia and Pacific. However among African countries, there are wide disparities: 21 African countries have a better access than the world average, with 11 countries facing a duty on exports of less than 2%: Algeria, Angola, Botswana, Central Africa, Chad, Congo D.R., Equatorial Guinea, Gabon, Lesotho, Liberia and Libya. In fact, 32 countries have bad access to foreign markets as compared to the world average, with 13 countries facing an average duty on exports greater than 10%, and Malawi facing a stiff average of 23.1% tariff on its exports.

This contrasting picture on African access to foreign markets comes from two different effects. First, the structure of world protection is unequally distributed amongst sectors and across importers. Countries highly specialized in certain agricultural products, like meat, milk, sugar or some cereals or exporting to protectionist countries get penalized. This is what we call a composition effect. However, more preferential access to countries than rest of the world decreases the average duty on exports. This second effect is the true margin effect. If the composition effect is positive, even without preferences, a country benefits from a lower tariff than the world average. Positive true preference margin implies that the country benefits from preferences relative to the rest of the world and converse for negative true preference margin.

Table 3: Apparent margin and its decomposition for African countries 2004 (MAcMap HS6 database)

Country/Zone	Applied Duty	Apparent Margin	Composition Effect	True 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

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 the country $i's$ apparent margin (AM_i) which is the difference between the applied duty faced by 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 $MFND_i$.

So the apparent margin can be rewritten as:

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

$\quad = (MFND_W - MFND_i) + ((MFND_i - AD_i) - (MFND_W - AD_W))$

The first term under parenthesis compares average market accesses for the world and for i without taking into account preferences; it captures the composition effect: if $MFND_W$ is greater than $MFND_i$ this cannot be attributed to preferences given to 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). It is the true preference margin (see Bouet et al 2005 for more details and more comprehensive results).

Table 3 shows that if African countries benefit from a lower average duty faced on exports than the world, by 0.3%, this is due to a composition effect which is favorable (0.6%). Specializations in products (oil, gas, mineral products) which are not highly taxed throughout the world have a positive impact on market access in these countries. This average statistic hides significant heterogeneity across countries; exports from Malawi, Swaziland, Togo, Benin, Mauritius are penalized due to specialization in highly protected products while preferences compensate only partially (in absolute value true preference margins are less than the composition effect). On the other side, Congo DR, Chad, Libya and Lesotho have a positive composition effect. For Africa as a whole, the true preference margin is negative: 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 year 2001 for the full sample. In Table 5 the sample only includes low income countries. Results for 2004 are presented in Tables 6 and 7. The infrastructure variables that we include in table 4 are respectively road length as a proportion of population and phones per thousand people in the exporting country. Results are robust to alternate measures of transport and communication infrastructure viz. roads as a percentage of land area, percent of roads that are paved and fixed phone lines per thousand people (as well as total fixed and mobile lines per thousand people). Similarly, results are robust to inclusion of the importing country infrastructure. The importing country infrastructure variables contribute to the multilateral resistance terms as the exporting country infrastructure. Same specifications have been run for the pooled sample (not reported here).

Table 4: Heckman regression for 2001- (Full sample)

COEFFICIENT	Log trade (not including infrastructure) Logtrade	Likelihood (not including infrastructure) likelihood	Log trade (including infrastructure) logtrade	Likelihood (including infrastructure) likelihood
Log GDP of exporter	1.034***	0.326***	1.013***	0.338***
	(0.013)	(0.019)	(0.014)	(0.022)
Log GDP of importer	0.896***	0.270***	0.900***	0.280***
	(0.013)	(0.021)	(0.013)	(0.021)
Log of bilateral distance	-1.325***	-0.258***	-1.330***	-0.283***
	(0.037)	(0.053)	(0.036)	(0.054)
Log of distance of exporter from the world	0.630***	-0.525***	0.725***	-0.391***
	(0.12)	(0.15)	(0.12)	(0.15)
Log of distance of importer from the world	0.438***	-0.272**	0.437***	-0.244*
	(0.11)	(0.13)	(0.11)	(0.13)
Log of bilateral tariff	0.0684	0.120**	0.0855*	0.143***
	(0.047)	(0.051)	(0.047)	(0.052)
Log of relative import protection	0.0397	0.0970**	0.0327	0.0896**
	(0.035)	(0.045)	(0.034)	(0.045)
Log of relative export protection	-0.117***	-0.185***	-0.135***	-0.207***
	(0.037)	(0.034)	(0.037)	(0.034)
Log of ad valorem equivalent of non-tariff barriers	-0.0676***	-0.0460*	-0.0686***	-0.0502**
	(0.022)	(0.025)	(0.022)	(0.025)
Landlocked exporter dummy	-0.00711	-0.0803	-0.0178	-0.0681
	(0.059)	(0.056)	(0.059)	(0.058)
Landlocked importer dummy	-0.446***	-0.193***	-0.446***	-0.211***
	(0.062)	(0.063)	(0.061)	(0.063)
Whether the trading countries share a common border	1.037***	0.0717	1.070***	0.135
	(0.14)	(0.34)	(0.14)	(0.35)
Whether the trading countries share a common language	0.694***	0.242***	0.682***	0.214***
	(0.065)	(0.082)	(0.065)	(0.082)
Whether the trading countries are related through a colonial relationship	0.698***	4.617	0.709***	4.621
	(0.19)	(0)	(0.19)	(0)
Africa export dummy	**-0.272***	**-0.0647**	**-0.0711**	**0.135****
	(0.058)	(0.056)	(0.069)	(0.067)
Historical frequency of positive trade		2.366***		2.303***
		(0.092)		(0.092)
Logmobile density of exporter			0.0565***	0.0370*
			(0.016)	(0.020)
Log road density exporter			0.0651***	0.138***
			(0.025)	(0.033)
Constant	-29.30***	-9.583***	-28.88***	-9.519***
	(0.61)	(0.88)	(0.62)	(0.89)
Observations	8563	8563	8563	8563

Source: Author's calculations – Standard errors in parentheses

Table 5: Heckman regression 2001 (low income exporter sample)

Coefficient	Logtrade (not including infrastructure)	Likelihood (not including infrastructure)	Logtrade (including infrastructure)	Likelihood (including infrastructure)
COEFFICIENT	logtrade	likelihood	logtrade	likelihood
Log GDP of exporter	0.819***	0.302***	0.889***	0.353***
	(0.054)	(0.046)	(0.056)	(0.050)
Log GDP of importer	0.661***	0.267***	0.682***	0.274***
	(0.043)	(0.034)	(0.041)	(0.035)
Log of bilateral distance	-0.929***	-0.131	-1.022***	-0.162*
	(0.12)	(0.089)	(0.12)	(0.090)
Log of distance of exporter from the world	1.176*	0.0367	0.971	0.343
	(0.62)	(0.43)	(0.62)	(0.45)
Log of distance of importer from the world	-0.223	-0.654***	-0.201	-0.637***
	(0.28)	(0.20)	(0.28)	(0.20)
Log of bilateral tariff	0.346***	0.208**	0.448***	0.195**
	(0.12)	(0.089)	(0.12)	(0.091)
Log of relative import protection	-0.0718	-0.0391	-0.120	-0.0569
	(0.096)	(0.076)	(0.093)	(0.076)
Log of relative export protection	-0.326***	-0.173***	-0.413***	-0.153***
	(0.088)	(0.057)	(0.088)	(0.059)
Log of ad valorem equivalent of non-tariff barriers	-0.0676	-0.0572	-0.0828	-0.0607
	(0.060)	(0.042)	(0.058)	(0.042)
Landlocked exporter dummy	0.0201	-0.117	-0.0675	-0.0290
	(0.12)	(0.083)	(0.13)	(0.098)
Landlocked importer dummy	0.205	-0.155	0.130	-0.168
	(0.17)	(0.11)	(0.17)	(0.11)
Whether the trading countries share a common border	1.357***	0.175	1.329***	0.206
	(0.39)	(0.39)	(0.38)	(0.39)
Whether the trading countries share a common language	0.842***	0.172	0.722***	0.159
	(0.16)	(0.13)	(0.15)	(0.13)
Whether the trading countries are related through a colonial relationship	2.354*	3.787	2.663**	3.791
	(1.22)	(0)	(1.18)	(0)
Africa export dummy	**-0.148**	**0.240****	**0.152**	**0.278*****
	(0.16)	(0.10)	(0.16)	(0.11)
Historical frequency of positive 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)
Logmobile density of exporter			0.0714	0.225**
			(0.11)	(0.088)
Log road density exporter			0.474***	0.0334
			(0.076)	(0.054)
Observations	1883	1883	1883	1883

Source: Author's calculations – Standard errors in parentheses

Table 6: Heckman regression 2004 (full sample)

COEFFICIENT	Logtrade (not including infrastructure)	Likelihood (not including infrastructure)	Logtrade (including infrastructure)	Likelihood (including infrastructure)
Log GDP of exporter	1.091***	0.228***	1.096***	0.305***
	(0.051)	(0.051)	(0.034)	(0.045)
Log GDP of importer	0.798***	0.281***	0.810***	0.373***
	(0.061)	(0.054)	(0.041)	(0.038)
Log of bilateral distance	-1.144***	-0.285**	-1.152***	-0.274***
	(0.14)	(0.13)	(0.091)	(0.099)
Log of distance of exporter from the world	1.044**	-0.569	1.692***	-0.751**
	(0.48)	(0.39)	(0.33)	(0.33)
Log of distance of importer from the world	0.140	-0.770***	-0.0612	-0.381*
	(0.42)	(0.27)	(0.28)	(0.23)
Log of bilateral tariff	-0.691***	0.411***	-0.446***	0.301***
	(0.20)	(0.14)	(0.14)	(0.11)
Log of relative import protection	0.351***	-0.162	0.269***	-0.00415
	(0.13)	(0.10)	(0.090)	(0.080)
Log of relative export protection	0.360**	-0.180*	0.184*	-0.301***
	(0.16)	(0.11)	(0.11)	(0.088)
Log of ad valorem equivalent of non-tariff barriers	-0.00272	-0.162**	-0.0782	
	(0.090)	(0.064)	(0.058)	
Landlocked exporter dummy	-0.545**	-0.238*	0.00153	-0.355***
	(0.22)	(0.13)	(0.16)	(0.13)
Landlocked importer dummy	-0.675***	-0.525***	-0.789***	-0.355***
	(0.26)	(0.15)	(0.17)	(0.12)
Whether the trading countries share a common border	1.037**	4.458	1.027***	4.928
	(0.52)	(0)	(0.35)	(0)
Whether the trading countries share a common language	0.917***	0.0847	0.828***	0.102
	(0.26)	(0.20)	(0.18)	(0.16)
Whether the trading countries are related through a colonial relationship	0.342	2.328	0.194	2.773
	(1.10)	(0)	(0.74)	(0)
Africa export dummy	**-0.686*****	**-0.179**	**0.211**	**-0.127**
	(0.22)	(0.13)	(0.17)	(0.13)
Historical frequency of positive 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)
Logmobile density of exporter			0.386***	-0.0904**
			(0.050)	(0.045)
Log road density exporter			0.0837	0.200***
			(0.066)	(0.067)
Observations	3974	3974	3974	3974

Source: Author's calculations – Standard errors in parentheses

Table 7: Heckman regression (2004) – Low income exporter sample

COEFFICIENT	Logtrade (not including infrastructure)	Likelihood (not including infrastructure)	Logtrade (including infrastructure)	Likelihood (including infrastructure)
Log GDP of exporter	1.089***	0.290***	0.971***	0.0824
	(0.12)	(0.11)	(0.13)	(0.13)
Log GDP of importer	0.574***	0.137***	0.619***	0.180***
	(0.095)	(0.049)	(0.081)	(0.051)
Log of bilateral distance	-0.895***	-0.167	-1.050***	-0.215
	(0.27)	(0.14)	(0.23)	(0.15)
Log of distance of exporter from the world	1.733	-1.496*	1.532	-2.221**
	(1.96)	(0.87)	(1.76)	(0.94)
Log of distance of importer from the world	-0.361	-0.786**	-0.243	-0.775**
	(0.75)	(0.32)	(0.63)	(0.32)
Log of bilateral tariff	-0.0251	0.117	0.268	0.189
	(0.33)	(0.15)	(0.30)	(0.16)
Log of relative import protection	0.119	-0.0203	0.0565	-0.0274
	(0.19)	(0.087)	(0.16)	(0.089)
Log of relative export protection	-0.0560	-0.108	-0.339	-0.192
	(0.28)	(0.13)	(0.26)	(0.14)
Log of ad valorem equivalent of non-tariff barriers	-0.0205	-0.169	-0.0527	-0.181*
	(0.20)	(0.11)	(0.16)	(0.11)
Landlocked exporter dummy	-0.0885	-0.00545	-1.097*	-0.885***
	(0.33)	(0.13)	(0.60)	(0.28)
Landlocked importer dummy	-0.286	0.168	-0.340	0.185
	(0.43)	(0.19)	(0.36)	(0.19)
Whether the trading countries share a common border	1.297	4.623	1.241	4.684
	(1.20)	(0)	(1.02)	(0)
Whether the trading countries share a common language	0.577	0.276	0.460	0.416*
	(0.43)	(0.21)	(0.37)	(0.22)
Africa export dummy	**-0.0545**	**-0.358***	**0.0609**	**-0.267**
	(0.41)	(0.20)	(0.35)	(0.21)
Historical frequency of positive 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)
Logmobile density of exporter			-0.473*	-0.440***
			(0.25)	(0.12)
Log road density exporter			0.923***	0.342**
			(0.27)	(0.14)
Observations	1222	1222	1222	1222

Source: Author's calculations – Standard errors in parentheses

In the Heckman specifications, our exclusion variable is the historical frequency of positive trade as discussed above. 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 for African exporter 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 under-exporter. However, if the comparator is the rest of the world within the low income group, then African low income exporters do not under-export.[9] Note that given the global distribution of incomes, the low income exporter sample includes a

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[9] Though not presented here, Africa is not an under-importer. Also not presented here are the results indicating Africa as an under-exporter when we control for importing country infrastructure.

disproportionately large number of African countries. More importantly, in the presence of export country infrastructure the under-trading effect for Africa is lower. This under-trading effect (without inclusion of infrastructure) is robust to different specifications of the gravity model. The under-trading effect does get reduced with inclusion of infrastructure and in some specifications it vanishes altogether. Tables A.1 – A.4 in the appendix present the results from Log linear and Tobit specification of the gravity model. The status of Africa as an under-trader in the global sample and not as an under-trader in the low income sample holds true in all these specifications. Though not presented but the results hold for 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. Thus, infrastructure (or its correlates for example institutions) can be considered to be among the factors that account for at least part of under-trading by Africa. This follows from levels of trade related infrastructure being on an average lower in Africa than the rest of the world and the fact that trade facilitating infrastructure affect trade flows significantly.

5. Role of infrastructure in African trade

Having established that infrastructure is a potential factor for Africa's under-trading, we estimate their impacts on trade using a partial linear specification (as given in equation 7a) of the gravity model that allows for all possible interactions across the types of infrastructure. We consider two infrastructure variables— road and mobile density as interactions between them are easy to conceive.

The impact of increment in mobile and road density on trade for the countries in the sample with pooled data for 2001 and 2004 range respectively from 0.0 to 0.88 (for most countries this impact is evaluated at less than 0.4) and from 0.0 to 0.7. While mobiles density has 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 these two periods. Thus, when marginal impacts of mobile are estimated for 2001 and 2004 separately, the impacts are significantly higher in 2004. We interpret this result as possibly capturing the role of network effects. Network effects imply that starting from a higher base, the same percentage increase in mobile density is much more effective since there already exists a large set of mobile users.

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

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

Similarly, statistically significant and quantitatively important impacts on trade are estimated for several African countries also in case of road density. The highest estimated marginal impact of road for African countries is nearly 0.7% in case of Sudan.

Also, greater than 0.1% impact on trade from a 1% increase in road density is observed in case of several African countries, for example Guinea Bissau, Mauritania, Gambia and Madagascar.

Figure 2: Marginal impact of phone and phone density (Pooled sample)

Marginal impact of phone and phone density
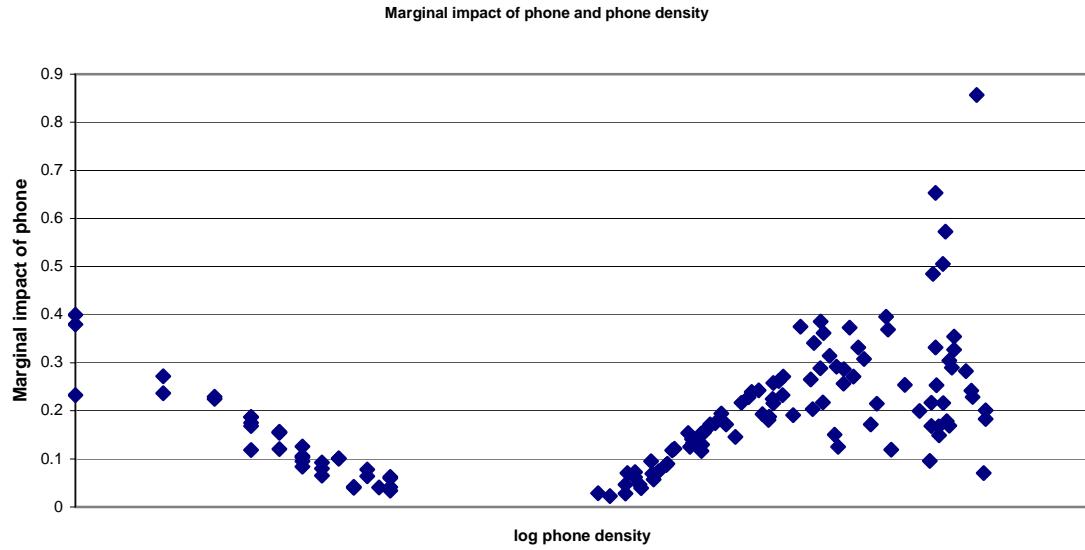
Source: Author's calculations

Figure 3: Marginal impact of road and road density (Pooled sample)

Marginal impact of road and road densities
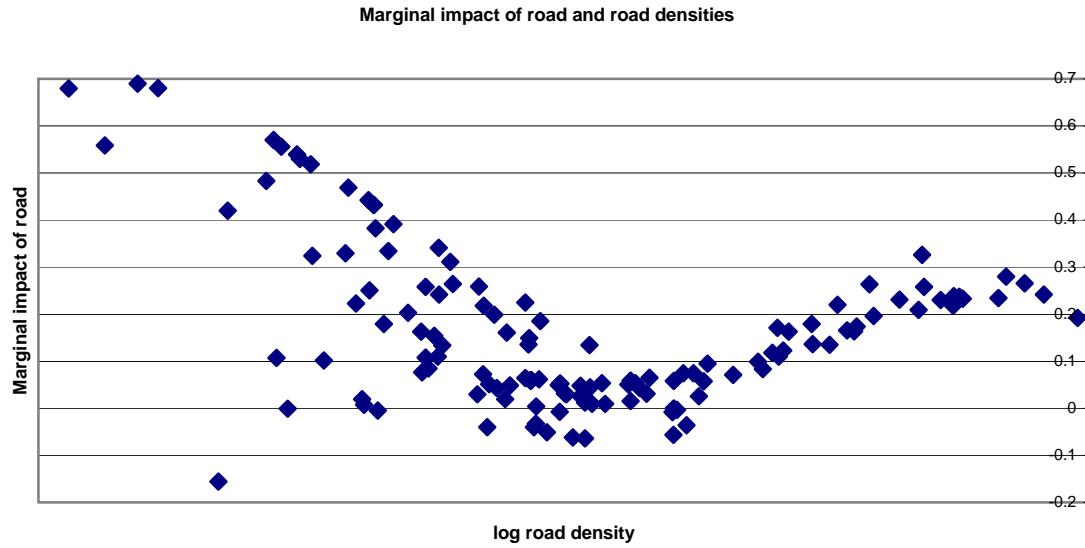
Source: Author's calculations

Figures 2 and 3 plot the variations of the estimated marginal impacts with phone and road densities respectively. Note that as densities of either road or phone vary across countries, there is no reason a priori to expect a pattern across estimated marginal impacts. The impact on trade is estimated on the aggregate level of exports and the effect of same infrastructure on aggregate exports is likely to vary based on the composition of exports and other country characteristics, some but not all of which have been controlled for parametrically. Yet, from the estimated marginal impacts, there seems to be summary

evidence of both diminishing returns and network effects with estimated impacts falling with rising densities in some range and then tending to increase when a certain level of density is reached for either phone or road.

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 tech exports (greater than 25%)	0.13	0.22	0.13	0.11
Share of high tech 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 : greater than median , low: smaller than median				
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 documents 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

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 separately. The average estimated marginal impact of road in Africa is fairly constant across all groupings. Among low income countries, the impacts are higher in Africa than elsewhere. The impacts vary significantly also with the composition of exports. The impact of greater phone density is unambiguously higher greater is the share of high technology exports or service exports in Africa.

Based on the cost of doing trade from the World Bank, in table 8, we classify the countries as low costs of trade (below the median - in terms of documents requirements, time to export and costs to export) and high costs of trade respectively. Importantly, in countries both in Africa and elsewhere, wherever the existing costs of trade are higher, the marginal impacts of phone connectivity are higher. This is true both within Africa and in rest of the world. Indeed, part of greater costs to trade or time taken to trade are by themselves a consequence of lower levels of infrastructure.

6. Complementarities in infrastructure

Given the specification of the partial linear gravity model, the marginal impact of either of the two infrastructures depends upon the level of the other infrastructure as discussed

above. 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 average level of exports significantly higher when the level of other infrastructure is higher. Thus, for complementarity between phone and road connectivity, this counterfactual exercise requires assigning same level of road density to all countries in the sample and obtaining marginal impacts of mobile for different mobile densities.

Figure 4: Infrastructure complementarities

Complementarity for Mobile Density with road density

M obile Density
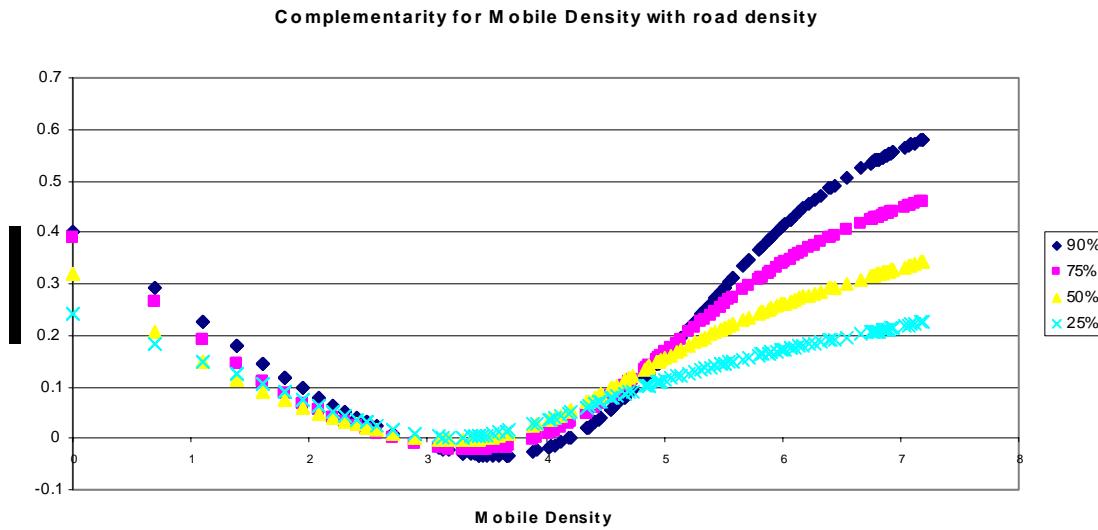
Source: Author's calculations

Figure 4 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 i.e. are 25th, 50th, 75th, and 90th percentile obtained from the empirical distribution of observed road density. In the figure, different lines are associated with these four different levels of hypothetical road density. As expected, we witness local complementarity i.e that is when the log of phone density is between 5 and 7 we observe an upward shift in the mobile density plot. Complementarity is not observed in lower values for mobile density.

When the mobile density is too low then it is expected that increasing road density will not affect the marginal impact of mobile density due to the absence of a critical level of mobile density. Only after a critical level of mobile density is reached, one observes complementarity. This idea of thresholds has increasingly been recognized through use of threshold regressions in estimating the augmented production functions (for example see 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 and unknown threshold point compared with the threshold regressions framework.

Even though it is natural to expect possibilities of such complementarities, a relationship like this has formally not been established in the trade literature. Note that this relationship does not correspond to a positive relationship between road density and marginal impacts of mobile. Since 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. Hence, this complementarity implies that the gains

from investment in infrastructure (in terms of its impact on trade) for any country is higher, higher is the level of infrastructure that it is complementary to.

7. Conclusions and policy implications

The assessment of market access for Africa shows that on an average Africa enjoys good access to foreign markets. However, there are significant variations within Africa with some really low income countries like Malawi facing relatively 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 preference to Africa, we find that the current true preference margin for Africa is in fact negative. Thus, greater market access will help African exports but again the effects are likely to be disparate across countries.

The evidence, however, points that even if preferences can help raise the level of exports, it is likely that Africa will continue to trade less than it ideally 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 under-trading effect. However, the impact of infrastructure on trade exhibits significant complementarities. Thus, policy interventions that develop infrastructure in a piece meal fashion in Africa are likely to yield much lower returns than when they develop infrastructure comprehensively.

Further, these results on significant impacts of infrastructure on trade have important policy implications especially in light of the "aid for trade" policy agenda that has surfaced in the Doha round. Essentially, the principle behind aid for trade agenda is realization of the fact that observed low trading by countries with already good market access (in Africa or elsewhere but mainly low income countries) implies that market access is not the only reason for declining trade performance of certain countries. The result that infrastructure has important and significant effect on trade, basically supports this premise behind the aid for trade agenda.

References

Anderson J, van Wincoop E. Gravity with Gravitas: a Solution to the Border Puzzle. American Economic Review 2003; 93; p. 170-92

Bouët A, Decreux Y, Fontagné L, Jean S, Laborde D. A consistent measure of applied protection. Review of International Economics 2008; forthcoming

Bouët A, Fontagné L, Jean S, 2005. Is Erosion of Preferences A Serious Concern? In: Anderson K, Martin W, (Eds), Agricultural Trade Reform and the Doha Development Agenda. Washington OUP and the World Bank, 2005. p. 161-193

Bougheas

Carroll RJ, Fan J, Gijbels I, Wand MP. Generalized partially linear single index model. Journal of the American Statistical Association 1997; 92; 477-489

Coe DT, Hoffmaister AW. North-South Trade: Is Africa Unusual? IMF Working Paper 1998; 98/94; p.1-27

Fan J. Design-adaptive nonparametric regression. Journal of the American Statistical Association 1992; 87;p. 998-1004

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

Foroutan F, Pritchett L.Intra-Sub-Saharan Trade: Is it too little? Journal of African Economies 1993; 2; 1; p. 74-105.

Francois J, Machin M,

Gaulier G, Zignago S, Sondjo D, Sissoko A, Paillacar R. BACI: A World Database of International Trade Analysis at the Product-level. CEPII Working Paper 2008; forthcoming.

Helpman E, Melitz M, Rubinstein Y. Estimating Trade Flows. Trading Partners and Trading Volumes. *Mimeo.* Harvard University 2007.

Hurlin

Kee HL, Nicita A, Olarreaga M. Estimating Trade Restrictiveness Indices. http://siteresources.worldbank.org/INTRES/Resources/OTRIpaper.pdf

Linders G,Jan M, de Groot HLF. Estimation of the Gravity Equation in Presence of Zero Flow. Tinbergen Institute Discussion Paper. 2006;72/3

Robinson PM. Root-N-Consistent Semiparametric Regression. Econometrica 1988; 56; 4; p. 931-954

Rodrik D. Trade Policy and Economic Performance in Sub-Saharan Africa. National
        Bureau of Economic Research Working Paper 6562 1998

Sachs JD, Warner AM. Sources of Slow Growth in African Economies. Journal of
        African Economies 1997; 6; 3 p. 335-376

Subramanian A, Tamirisa N.Africa's Trade Revisited. IMF Working Paper 1997; 01-33;
        p. 1-31.

Subramanian A, Wei .

World Bank. Can Africa Claim the 21st Century? World Bank 2000; Washington, DC.

Table A.1: Log linear specification of the gravity model 2001

COEFFICIENT	Logtrade (full sample not including infrastructure)	Logtrade (full sample including infrastructure)	Logtrade (low income exporter sample not including infrastructure)	Logtrade (low income exporter sample including infrastructure)
Log GDP of exporter	1.115***	1.080***	1.080***	1.157***
	(0.010)	(0.012)	(0.040)	(0.041)
Log GDP of importer	0.965***	0.966***	0.893***	0.895***
	(0.012)	(0.012)	(0.032)	(0.031)
Log bilateral distance	-1.437***	-1.437***	-1.257***	-1.329***
	(0.034)	(0.034)	(0.11)	(0.11)
Log distance exporter from world	0.752***	0.876***	1.181*	1.070*
	(0.11)	(0.11)	(0.61)	(0.61)
Log distance importer from world	0.468***	0.469***	-0.379	-0.322
	(0.11)	(0.11)	(0.28)	(0.27)
Log bilateral tariff	-0.00711	-0.0119	-0.0134	-0.0347
	(0.016)	(0.016)	(0.028)	(0.027)
Log ad valor. equivalent of non tariff barriers	-0.0799***	-0.0808***	-0.0763	-0.0886
	(0.021)	(0.021)	(0.057)	(0.056)
Landlocked exporter dummy	-0.0675	-0.0744	-0.0516	-0.0357
	(0.061)	(0.061)	(0.12)	(0.13)
Landlocked importer dummy	-0.496***	-0.495***	0.114	0.0415
	(0.062)	(0.062)	(0.15)	(0.15)
Whether the trading countries share a common border	0.998***	1.045***	1.358***	1.312***
	(0.13)	(0.13)	(0.37)	(0.34)
Whether the trading countries share a common language	0.746***	0.725***	1.084***	0.959***
	(0.065)	(0.065)	(0.15)	(0.15)
Colony	0.629***	0.653***	2.090**	2.446***
	(0.13)	(0.14)	(1.00)	(0.80)
Africa export dummy	**-0.306***	**-0.0557**	**0.303***	**0.602***
	(0.066)	**(0.074)**	**(0.15)**	**(0.15)**
Log mobile density of exporter		0.0811***		0.270***
		(0.016)		(0.100)
Log road density of exporter		0.0619**		0.460***
		(0.025)		(0.070)
Constant	-32.74***	-32.16***	-31.52***	-30.09***
	(0.51)	(0.52)	(1.98)	(2.08)
Observations	7119	7119	1286	1286
R-squared	0.74	0.74	0.54	0.56

Source: Author's calculations – Standard errors in parentheses

Table A.2: Tobit model for 2001 sample

COEFFICIENT	Full sample (Not including infrastructure)	Full sample (including infrastructure)	Low income exporter sample (Not including infrastructure)	Low income exporter sample (including infrastructure)
Log GDP of exporter	1.447***	1.369***	1.720***	1.858***
	(0.014)	(0.017)	(0.068)	(0.069)
Log GDP of importer	1.252***	1.250***	1.542***	1.532***
	(0.016)	(0.016)	(0.048)	(0.047)
Log bilateral distance	-1.831***	-1.823***	-2.031***	-2.112***
	(0.048)	(0.047)	(0.16)	(0.16)
Log distance exporter from world	0.628***	0.844***	1.040	1.467*
	(0.15)	(0.15)	(0.85)	(0.86)
Log distance importer from world	0.429***	0.441***	-1.339***	-1.212***
	(0.14)	(0.14)	(0.39)	(0.38)
Log bilateral tariff	0.0364*	0.0276	0.0129	-0.0263
	(0.019)	(0.019)	(0.043)	(0.043)
Log ad valor. equivalent of non tariff barriers	-0.145***	-0.147***	-0.180**	-0.189**
	(0.029)	(0.029)	(0.084)	(0.082)
Landlocked exporter dummy	-0.326***	-0.315***	-0.478***	-0.322*
	(0.076)	(0.076)	(0.17)	(0.19)
Landlocked importer dummy	-0.765***	-0.764***	-0.427*	-0.479**
	(0.079)	(0.078)	(0.24)	(0.23)
Whether the trading countries share a common border	0.941***	1.048***	1.518***	1.484***
	(0.20)	(0.20)	(0.58)	(0.57)
Whether the trading countries share a common language	0.956***	0.909***	1.437***	1.285***
	(0.085)	(0.085)	(0.23)	(0.22)
Colony	0.185	0.233	2.052	2.627
	(0.26)	(0.26)	(1.91)	(1.87)
Africa export dummy	**-0.386***	**0.0979**	**1.215***	**1.535***
	(0.074)	**(0.087)**	**(0.21)**	**(0.22)**
Log mobile density of exporter		0.171***		0.676***
		(0.021)		(0.16)
Log road density of exporter		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

Source: Author's calculations – Standard errors in parentheses

Table A.3: Log linear specification 2004

COEFFICIENT	Logtrade (full sample not including infrastructure)	Logtrade (full sample including infrastructure)	Logtrade (low income exporter sample not including infrastructure)	Logtrade (low income exporter sample including infrastructure)
Log GDP of exporter	1.245***	1.220***	1.283***	1.072***
	(0.017)	(0.018)	(0.069)	(0.10)
Log GDP of importer	0.870***	0.874***	0.794***	0.804***
	(0.021)	(0.020)	(0.056)	(0.054)
Log bilateral distance	-1.310***	-1.304***	-1.104***	-1.203***
	(0.057)	(0.056)	(0.19)	(0.18)
Log distance exporter from world	0.357**	0.589***	1.089	-0.112
	(0.16)	(0.17)	(1.42)	(1.55)
Log distance importer from world	-0.627***	-0.646***	-1.517***	-1.305***
	(0.18)	(0.18)	(0.50)	(0.48)
Log bilateral tariff	0.0166	0.0114	0.0391	-0.00112
	(0.025)	(0.025)	(0.046)	(0.044)
Log ad valor. equivalent of non tariff barriers	-0.0536	-0.0602*	-0.120	-0.147
	(0.036)	(0.036)	(0.11)	(0.11)
Landlocked exporter dummy	-0.122	0.0990	-0.0123	-1.297**
	(0.098)	(0.099)	(0.26)	(0.50)
Landlocked importer dummy	-0.563***	-0.574***	-0.244	-0.325
	(0.11)	(0.11)	(0.34)	(0.34)
Whether the trading countries share a common border	0.984***	1.018***	0.816	0.807
	(0.23)	(0.22)	(0.77)	(0.77)
Whether the trading countries share a common language	0.809***	0.760***	1.112***	1.029***
	(0.11)	(0.11)	(0.31)	(0.31)
colony	-0.484	-0.491	0	0
	(0.30)	(0.30)	(0)	(0)
Africa export dummy	**-0.300***	**-0.0305**	**-0.0451**	**0.330**
	(0.11)	**(0.12)**	**(0.27)**	**(0.26)**
Log mobile density of exporter		0.183***		-0.654***
		(0.029)		(0.18)
Log road density of exporter		-0.0658*		1.102***
		(0.039)		(0.20)
Constant	-31.35***	-32.71***	-32.44***	-16.18***
	(0.80)	(0.86)	(4.08)	(6.21)
Observations	3826	3826	661	661

Source: Author's calculations – Standard errors in parentheses

Table A.4: Tobit regression (2004 sample)

COEFFICIENT	Full sample (Not including infrastructure)	Full sample (including infrastructure)	Low income exporter sample (Not including infrastructure)	Low income exporter sample (including infrastructure)
Log GDP of exporter	1.323***	1.298***	1.393***	0.963***
	(0.020)	(0.020)	(0.085)	(0.11)
Log GDP of importer	0.948***	0.951***	0.984***	0.988***
	(0.023)	(0.023)	(0.068)	(0.065)
Log bilateral distance	-1.398***	-1.393***	-1.448***	-1.538***
	(0.060)	(0.060)	(0.20)	(0.19)
Log distance exporter from world	0.229	0.479**	0.536	-1.824
	(0.19)	(0.20)	(1.47)	(1.50)
Log distance importer from world	-0.812***	-0.832***	-2.401***	-2.090***
	(0.18)	(0.18)	(0.50)	(0.49)
Log bilateral tariff	0.0634***	0.0582**	0.0995**	0.0419
	(0.024)	(0.024)	(0.050)	(0.049)
Log ad valor. equivalent of non tariff barriers	-0.0943**	-0.0992**	-0.238**	-0.267**
	(0.039)	(0.039)	(0.12)	(0.12)
Landlocked exporter dummy	-0.190*	0.0132	-0.311	-2.687***
	(0.098)	(0.11)	(0.24)	(0.45)
Landlocked importer dummy	-0.670***	-0.677***	-0.613	-0.646*
	(0.12)	(0.11)	(0.38)	(0.37)
Whether the trading countries share a common border	1.064***	1.089***	0.659	0.650
	(0.23)	(0.23)	(0.85)	(0.81)
Whether the trading countries share a common language	0.882***	0.838***	1.141***	1.170***
	(0.12)	(0.12)	(0.33)	(0.32)
colony	-0.732	-0.736		
	(0.50)	(0.50)		
Africa export dummy	**-0.431***	**-0.169**	**-0.235**	**0.299**
	(0.099)	**(0.11)**	**(0.30)**	**(0.29)**
Log mobile density of exporter		0.166***		-1.185***
		(0.033)		(0.18)
Log road density of exporter		-0.0338		1.610***
		(0.044)		(0.21)
Constant	-33.87***	-35.02***	-33.95***	-5.511
	(0.90)	(0.95)	(4.15)	(5.77)
Observations	3974	3974	725	725

Source: Author's calculations – Standard errors in parentheses