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South–South Trade: Geography Matters

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Intra-subsaharan African trade appears to be very limited, an outcome that is often justified on the grounds of the size of the exporting and the importing economies. If that were the explanation, there would be no untapped trade potential. We argue instead that the main determinant of this 'missing trade' is geography. Being landlocked (and poor) translates into very high trade costs. In this paper, we try to measure the impact of geographical impediments on South–South trade. We focus on the intra and extra regional trade of the countries belonging to the West African Economic and Monetary Union, which have been involved in an integration process since the early days of their independence. We derive and estimate an Armington-based model highlighting the impact of geography and infrastructures on bilateral trade flows within this region.

1. The Puzzle

'The road to hell is unpaved', according to a journalist riding a beer truck from Douala to Bertoua, two towns in Cameroon separated by less than 500 km. Indeed, 'according to a rather optimistic schedule, it should have taken 20 hours, including overnight rest. It took four days. When the truck arrived, it was carrying only two-thirds of its original load'.[3]

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[3] The Economist print edition 12 September 2002.

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Table 1: *The Disadvantage of Landlocked Countries*

	Developing Countries				Developed Countries
	Africa	Asia	America	Mideast	
Landlocked					
Export	0.70	0.54	1.49		69.60
GDP	3.14	2.16	7.90		149.23
Export/GDP	0.22	0.25	0.19		0.47
Non-landlocked					
Export	4.63	61.37	13.77	22.00	232.80
GDP	13.22	141.45	66.57	54.69	1178.55
Export/GDP	0.35	0.43	0.21	0.40	0.20

Sources: World Development Indicators 2001 and our calculations.
Unit: billion US$, current value 2000.

How geography and infrastructure affect trade flows among developing countries is not anecdotal. Geography may explain and lock in inequalities among nations (Sachs, 2001): a glance at the world economy points to developing landlocked countries only loosely integrated in international trade, as can be seen in Table 1.

Landlocked developing countries are less involved in international trade than landlocked developed countries. The export to GDP ratio for developing landlocked countries is less than 30%, compared with 50% for developed landlocked countries. Turning to non-landlocked countries, this ratio is respectively about 40% and 20% for developing and developed countries (the exception being non-landlocked Latin American developing countries).

The poor performance of Southern countries is confirmed by a simple gravity regression on a sample of 84 developed and developing exporters as can be seen in Table A1 in the Appendix. Controlling for distance, GDP, GDP per capita, contiguity and common language variables, it appears that European landlocked countries trade 30% less than all other countries in the world (landlocked and coastal, developed and developing), while non-European landlocked countries trade 40% less;[4] African trade on average

[4] European landlocked countries being Austria, Switzerland, Czech Republic and Hungary.

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60% less. Hence, landlockedness and more generally geography have no straightforward impact on trade; the explanation is a combination of geography and other development-related determinants.

Such evidence may explain the limited benefits of South–South trade agreements so far (Greenaway and Milner, 1990): intra-regional trade (particularly in subsaharan Africa) remains very low. In the West African Economic and Monetary union (WAEMU), for instance, the share of intra-regional trade in total trade did not exceed 3% during the 1990s.[5]

This weakness of South–South trade raises three issues that will be addressed in this paper:

1. What is the magnitude of untapped trade potential in the South? Departing from the notion of a country's optimal level of trade (Havrylyshyn, 1985), trade economists generally focus on residuals of a gravity model to assess trade potentials. Based on the latter approach, Foroutan and Pritchett (1993) claimed that there was no untapped potential in subsaharan Africa intra-regional trade.
2. What responsibility does geography bear?[6]Amjadi and Yeats (1995) found that the relatively low level of subsaharan African exports was essentially due to high transport costs.[7] Limao and Venables (2001) suggested a significant impact of transportation infrastructure quality on transport costs and, consequently, on trade flows.
3. Is the traditional gravity-type methodology a suitable econometric device to sort out these effects? Fontagné *et al*. (2002) stressed an heterogeneity problem: including developing and developed countries in a same regression will yield biased estimators.

[5] This regional agreement created in the 1960s by some former French colonies in West Africa consists today of eight countries: Benin, Burkina Faso, Cote d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo (see Figure 1).

[6] By geography, we mean physical geography as well as infrastructure endowments. See Henderson *et al*. (2001) for a review of the literature and Limao and Venables (2001) for an attempt to measure the impact of infrastructure and geographical location of a country on transport costs.

[7] They examine net freights and insurance payments from the IMF balance of payments statistics.

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These contributions deserve credit for giving scientifically-based answers to such contentious questions, but are missing an explicit model taking into account the geographical and infrastructural features which seem to be sizeable barriers to trade in subsaharan Africa (SSA). Against this background, this paper aims at assessing the importance of SSA countries' geographical and infrastructural disadvantages by focusing on their intra- and extra-regional trade flows. We limit our investigation to the WAEMU countries for which data on intra-regional trade and infrastructure are available, and we include in addition their trade flows with OECD countries in order to take their external openness into account.

The remainder of the paper proceeds as follows. Some stylised facts on geographical and infrastructural disadvantages of the WAEMU are detailed in Section 2. An Armington-based trade equation is derived in Section 3. In Section 4, we first discuss econometric issues raised by the data we use, then estimate a traditional gravity model for the sake of comparison and carry out product-specific estimations, and finally estimate the Armington-based model. The last section concludes.

2. Some Stylised Facts

The long experience in intra-regional cooperation makes the WAEMU a good case study to consider issues related to South–South trade. The WAEMU, formed in 1963, was until 1994 a monetary union to consolidate the common currency used within French colonies. During the 1990s, the drastic economic situation faced by these countries encouraged them to reinforce their solidarity in a deeper economic integration. Whether this region is an optimal currency area and how it may impact trade is not examined here (see Bénassy-Quéré and Coupet, 2005): we will concentrate on trade issues.

2.1 Road Infrastructures

The WAEMU comprises five coastal countries (Benin, Cote d'Ivoire, Guinea-Bissau, Senegal and Togo) and three landlocked ones (Burkina Faso, Mali and Niger). More than three quarters of this area is located in the Sahel and two coastal countries (Senegal and

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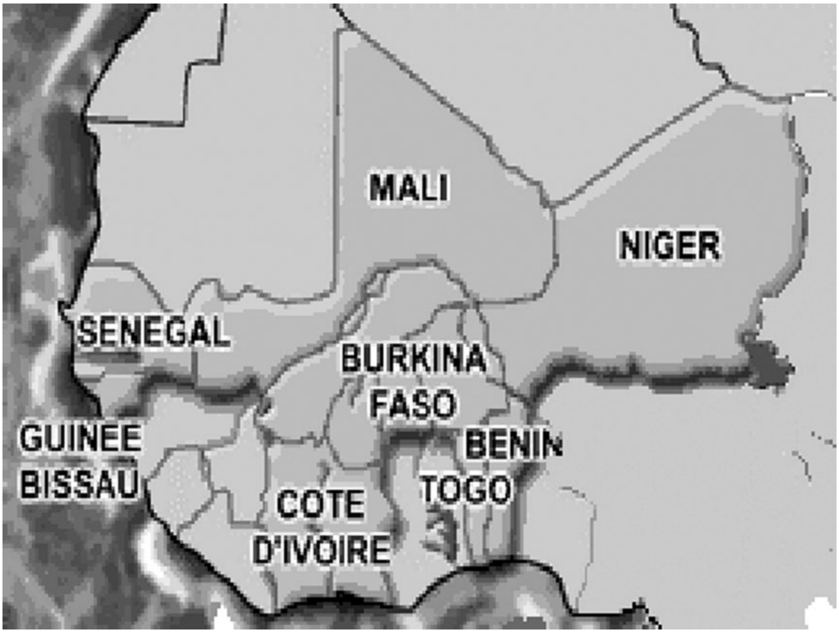

Figure 1: *The West African Economic and Monetary Union*. Source: www.uemoa.int

Guinea-Bissau) are significantly remote from the other members (see Figure 1).

Roads provide the main transportation infrastructure used for intra-regional trade (more than 90%).[8] The road network of the union is 146,352 km long with only 14% paved. This network is unevenly distributed among members (Table 2) and is integrated in the whole West African roads network, which comprises three types of road: the coastal roads linking coastal countries, the corridors linking landlocked countries to the sea, and the trans-sahel road from the border between Niger and Chad to Senegal. The coastal countries, representing 20% of the union surface area, concentrate more than 70% of the union roads.

Cote d'Ivoire accounts for about half of the whole union road network and more than a quarter of paved roads, and Senegal has

[8] Estimation of the transport department of WAEMU Commission in 2001. All the figures on infrastructure have been evaluated by the commission for the period 1996–1998. We do not have more recent data.

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Table 2: *Roads Distribution Throughout the WAEMU*

Country	Roads (km)	Proportion Paved (%)	Density (per 100 km^2)
BEN	13,842	9	10.8
BFA	13,117	14	6.7
CIV	68,351	8	17.0
MLI	14,776	17	2.0
NER	13,800	25	2.7
SEN	14,358	29	21.1
TGO	8,108	20	28.4
Union	146,352	14	5.9

Sources: WAEMU commission.

the next largest network with a better percentage of pavement (nearly 30%). Togo has the smallest road network but the highest road density (nearly 30 km of road per 100 km^2). The average road density of the union is about 5.9 km per 100 km^2 and only 14% of the union roads network is paved.

The Inter-state roads network is 13,202 km long, of which 80% are paved.[9] Nevertheless, the road linking Senegal to Mali is poorly paved (only 31% of pavement), a situation that practically isolates Senegal and Guinea-Bissau from the other members of the union in terms of land transport.

2.2 *Border Infrastructures*

The union members have signed two multilateral conventions to regulate and facilitate road transport and transit across borders.[10] Despite these arrangements, limited border infrastructures are still hindering the development of intra-regional traffic.

[9] Inter-state roads are highways between countries. Table A2 in the Appendix gives an overview of these inter-state roads.
[10] Referring to the document 'Etude sur la facilitation du transport et du transit routier Inter-Etats' (1998), WAEMU Commission.

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Table 3: *Border Equipment and Accessibility to Some Trading Partners*

Border	Economic Centers	Distance (km)	Road Distance (km)	Proportion Paved (%)	Borders Scores
CIV-BFA	Abidjan–Ouagadougou	832	1,176	100	39
CIV-MLI	Abidjan–Bamako	925	1,184	100	56
BEN-TGO	Cotonou–Lomé	160	189	100	33
TGO-BFA	Lome–Ouagadougou	757	970	100	44
MLI-SEN	Bamako–Dakar	1044	1,486	31	22
BFA-NER	Ouagadougou–Niamey	415	537	100	44
BFA-MLI	Ouagadougou–Bamako	705	610	100	44
NER-BEN	Niamey–Cotonou	785	1,041	100	33

Sources: WAEMU commission and our calculations.

A survey funded by the WAEMU Commission provided information on custom offices (suitable or not, joined or not, adjacent or not), weighbridges, radios, documentation on tax, typewriters, parking and storage facilities.[11] Accordingly, a score combining all the available information on each category of border equipment can be calculated. The method is rather crude: at a border, if a given item of equipment or characteristic is available to both custom offices, the score is 2. When it is available to one office only, the score is 1, and 0 otherwise. These scores then add up to a percentage on a scale of border equipment (Table 3).

On the basis of this scoring, it appears that only borders between Cote d'Ivoire and Mali, Togo and Burkina Faso, Burkina Faso and Niger and Burkina Faso and Mali are close to the 50% score. In addition, these countries are connected with paved roads. In contrast, Table 3 stresses the remoteness of Senegal and Guinea-Bissau from the other members of the union.[12] Indeed, the score

[11] 'Rapport de synthèse préparatoire à la table ronde des bailleurs de fonds sur les infrastructures et le transport routier des Etats membres de l'UEMOA' (2000), WAEMU Commission.

[12] Note that these two countries are located at the far west of the Union (see Figure 1).

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between Mali and Senegal is the lowest (22%), and in addition only 31% of the Senegal–Mali inter-state road is paved, a fact that adds to the isolation of Senegal and Guinea-Bissau from the rest of the WAEMU countries.[13]

The extensive nature of the WAEMU and the poor quality of transport infrastructures forebode high inland trade costs and thus lower intra-regional trade flows. In the following section, we will develop a bilateral trade model and focus on geographical disadvantages in order to analyze the intra- and extra-trade of these southern countries. The structural model derived from the Armington assumption of country-specific products will then be estimated.

3. The Model

The strong non-linearity in the impact of income per capita on trade leads to biased parameter estimates in a sample of heterogeneous countries (Fontagné *et al.*, 2002). Here we address this problem by deriving a bilateral trade model built on the well-known Armington assumption. This approach yields a structural equation of bilateral trade.

Let us consider a two-region world: South and North. South represents a developing region (namely WAEMU countries) and North represents a developed region (namely OECD countries). We focus on Southern countries' import flows from their Southern and Northern partners. Southern countries are denoted by i, $i \in I = \{1, \ldots, I\}$ and Northern countries are denoted by k, $k \in K = \{1, \ldots, K\}$. According to the Armington assumption, goods are differentiated by their origin, and we assume that within each country j, there are N_j representative firms producing the country-specific good. We assume a constant and non-unit elasticity of substitution between all the differentiated goods. The representative consumer i in a southern country has the following utility function:

[13] Note for the sake of comparison that within the Union, 61% of the inter-state roads are paved on average.

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$$U_i = \left(\int_{j \in I \cup K} \int_{s \in N_j} m_{ijs}^{\sigma-1/\sigma} djds \right)^{\sigma/\sigma-1} \tag{1}$$

where m_{ijs} is the import of country i from firm s in country j and σ is the elasticity of substitution between varieties of the traded good.[14] The consumer problem is then to set his import for each differentiated good so as to maximise this utility function subject to the budget constraint:

$$Y_i = \int_{j \in I \cup K} \int_{s \in N_j} P_{ij} m_{ijs} \, djds \tag{2}$$

where Y_i is the income of the representative consumer in country i, P_{ij} is the price set by country j's firm in country i. $P_{ij} = P_j \tau_{ij}$ where P_j is the production price andτ_{ij} is an iceberg transport cost between countries i and j. This means that a firm producing in country j sets a price P_j, and the consumer in country i bears this price and also the cost (expressed in terms of the imported good) required to ship this good from the production country to the import country. We derive the first order conditions of the maximisation problem and combine them to obtain the following equation:

$$P_{ij} M_{ij} = \tau_{ij}^{1-\sigma} \left(\frac{P_j}{\left(\int_{j \in I \cup K} \int_{s \in N_j} \left(P_j \tau_{ij} \right)^{1-\sigma} djds \right)^{1/1-\sigma}} \right)^{1-\sigma} Y_i \, N_j \lambda^{-\sigma} \tag{3}$$

which indicates a gravity type relation: the cost insurance freight import value of country i from country j ($P_{ij} M_{ij}$) depends on the trade cost between these countries (τ_{ij}), the income of import country (Y_i), the production level of the export country captured

[14] Summing this quantity over the N_j representative firms yields $M_{ij} = \int_{s \in N_j} m_{ijs} \, ds$, the total import of country i from country j. Here, we only focus on the import flows M_{ij} and do not deal with the internal trade M_{ii} since we aim at describing only bilateral Southern trade flows.

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by the number of active firms (N_j) and a market potential term including characteristics of country j and those of the other trading partners (notice that λ is the Lagrange multiplier).

We can simplify this equation by re-expressing equation (3) relative to a reference country, so as to cancel out the nomimal market potential combining price and transport cost terms.[15] We use France as the reference country because of its historical ties with West African countries. This method will also correct for any 'colonisation effect' in WAEMU imports from OECD countries. Let us denote by E_{ij} the bilateral trade values ($P_{ij}\, M_{ij} = E_{ij}$). Equation (3) becomes:

$$\frac{E_{ij}}{E_{iFRA}} = \left(\frac{\tau_{ij}}{\tau_{iFRA}}\right)^{1-\sigma}\left(\frac{P_j}{P_{FRA}}\right)^{1-\sigma}\left(\frac{N_j}{N_{FRA}}\right). \qquad (4)$$

The left-hand side of equation (4) represents country i's imports from country j relative to country i's imports from France. The right-hand side represents three determinants of the relative bilateral trade: the relative transport costs, the relative production prices and the relative number of active firms in the exporting countries. Equation (4) is the structural equation we will estimate. The next step is to define relevant proxies for these determinants of the relative import flows.

The trade flows under consideration are WAEMU intra- and extra-regional import flows. We thus need to properly define internal and external geographical impediments to these trade flows.

In the intra-regional context, geographical impediments are fourfold as depicted in Figure 2:

1. A border factor (extra borders have to be crossed), which can be proxied by the number of borders to be crossed by the shipped good.
2. A distance factor which can be proxied by the road distance between capital cities.
3. A transit factor, which can be approximated by the road distance from the first border to the last border crossed by the imported good.
4. An infrastructure factor, which can be estimated by the percentage of paved roads between the two trading partners.

[15] This method has been used by Head and Mayer (2000).

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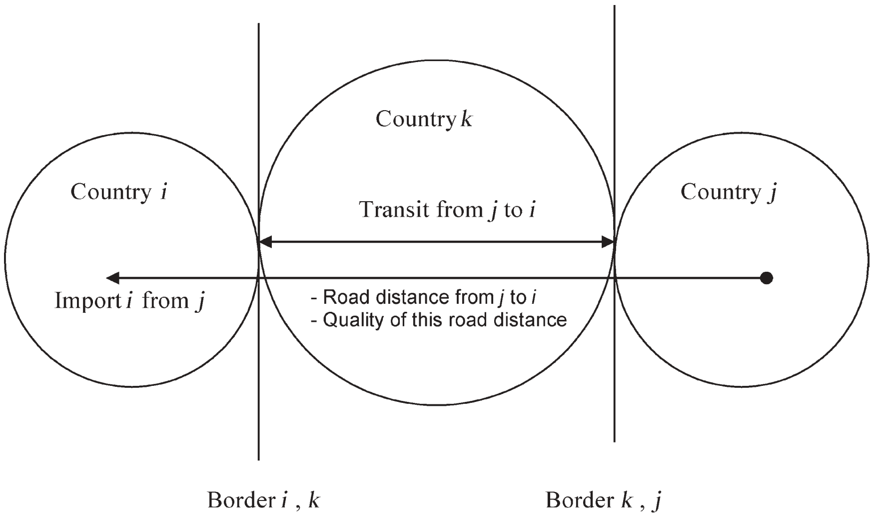

Figure 2: *Measuring Geographical Impediments to Intra-regional Trade*

In the extra-regional context, geographical impediments between a Northern (j) and a Southern (i) trading partner can be evaluated as follows:

1. the extra-regional distance (to be crossed by the imported good before reaching the developing region), which can be proxied by sea distance (SD_{ij}) for a coastal importer i, and by an average sea distance over all the southern coastal countries (δ_i) for a landlocked importer i;
2. the inland distance (distance to be crossed by the imported good within the developing region), which is zero for a coastal importer i and can be proxied by the average road distance over all the southern coastal countries (κ_i) for a landlocked importer i, since we do not know which coastal country is used as transit country.[16]

[16] We lose one dimension when using this average road distance to port but this remains statistically relevant. To recover this dimension, we constructed an adjusted road distance multiplying the average road distance to port by a remoteness parameter computed as the distance of a landlocked country to a given OECD partner divided by its average distance to all its OECD partners, but this adjusted variable yields non-significant parameters.

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The following non-linear transport cost function takes the regional and the extra-regional contexts into account:

$$\tau_{ij} = SD_{ij}^{\alpha_1} RD_{ij}^{\alpha_2} V_{ij} e^{\varepsilon_{ij}}. \tag{5}$$

SD_{ij} denotes sea distance between countries i and j, RD_{ij} denotes road distance between countries i and j, ε_{ij} is a disturbance term taking into account all unobservable sources of trade costs and V_{ij} is defined as follows:

$$V_{ij} = e^{\beta_1 FRENCH + \beta_2 WAEMU} \%PR_{ij}^{\gamma_1} TRANSIT_{ij}^{\gamma_2} e^{\gamma_3 NBORDER_{ij}} \tag{6}$$

where *FRENCH* is a dummy variable specifying two French speaking partners, *WAEMU* is a dummy variable specifying intra-regional trade, $\%PR_{ij}$ is the percentage of paved bilateral road, $TRANSIT_{ij}$ is the transit distance, that is the distance from the first border to the last border to be crossed by a shipped good and $NBORDER_{ij}$ is the number of borders to be crossed.

Lastly, we include dummies indicating whether country i is landlocked or not (LL_i), whether countries i and j are both WAEMU landlocked countries (LL_{ij}), as well as two indicators of remoteness REM_i and REM_j computed as $REM_i = 1/(\sum_{j \neq i} GDP_j/DIST_{ij})$ (borrowed from Head, 2003).

This transport cost function suggests a non-linear combination of sea and road distances between the two trading partners, and geographical and infrastructural characteristics of the Southern importer. We tentatively included the squared variable of $\%PR_{ij}$ in some specifications but the results were not satisfactory.

We now define proxies for the relative price and number of exporting firms. First, we rely on an aggregate price reflecting the exporter production price: the GDP deflator (from the World Development Indicators database, labelled as Π henceforth) of the exporter relative to this price proxy for France, adjusted by a factor η: $\Pi_j^{\eta}/\Pi_{FRA}^{\eta}$. The parameter η allows the trade elasticity with respect to the price proxy to depend on data rather than being constrained to be equal to one. Since we are dealing with international trade, the real exchange rate between the trading partners can matter, and following Soloaga and Winters (2001), we

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introduce a measure of real exchange rate deviation for the two trading partners. Let us call this variable *RER*, defined as $RER_j = e \times \Pi_{US}/\Pi_j$ where e is the value of 1 US dollar evaluated in the currency of country j. We expect this variable to matter less since the CFA franc (the currency of WAEMU countries) and the French franc were pegged until 2000. The relative formulation of this variable, as for the GDP deflator Π, will thus be $RER_j^{\delta}/RER_{FRA}^{\delta}$. Second, we proxy the number of active firms in an exporting country. Since this number captures the aggregate production level of the exporter, we rely on the exporter GDP adjusted by a factor φ. Here again, the factor φ allows the trade elasticity with respect to production level not to be constrained to one.

Using these different specifications in equation 4 yields:

$$\frac{E_{ij}}{E_{iFRA}} = \left\{ \begin{array}{ll} \left(\frac{SD_{ij}^{\alpha_1}}{SD_{iFRA}^{\alpha_1}} \frac{RD_{ij}^{\alpha_2}}{RD_{iFRA}^{\alpha_2}} \frac{V_{ij}}{V_{iFRA}} \right)^{1-\sigma} & \times \left(\frac{\Pi_j^{\eta}}{\Pi_{FRA}^{\eta}} \frac{RER_j^{\delta}}{RER_{FRA}^{\delta}} \right)^{1-\sigma} \\ \times \left(\frac{GDP_j^{\varphi}}{GDP_{FRA}^{\varphi}} \right) & \times \frac{e^{\varepsilon_{ij}}}{e^{\varepsilon_{iFRA}}} \end{array} \right\}. \tag{7}$$

If we re-express the relative road distance with regard to the location (coastal or landlocked) of country i and take the log of the latter expression, we end up with the following version of the structural equation:

$$\ln\left(\frac{E_{ij}}{E_{iFRA}}\right) = \left\{ \begin{array}{c} (1-\sigma)\alpha_1 \ln\left(\frac{SD_{ij}}{SD_{iFRA}}\right) + (1-\sigma)\alpha_2 \ln \frac{RD_{ij}}{RD_{iFRA}} \\ +(1-\sigma)\beta_1 FRENCH + (1-\sigma)\beta_2 WAEMU \\ +(1-\sigma)\gamma_1 \ln \%PR_{ij} + (1-\sigma)\gamma_2 \ln\ TRANSIT_{ij} \\ +(1-\sigma)\gamma_3 NBORDER_{ij} + \gamma_4 LL_i + \gamma_5 LL_{ij} \\ +\gamma_6 \ln\ REM_i + \gamma_7 \ln\ REM_j + (1-\sigma)\eta \ln\left(\frac{\Pi_j}{\Pi_{FRA}}\right) \\ +(1-\sigma)\delta \ln\left(\frac{RER_j}{RER_{FRA}}\right) + \varphi \ln\left(\frac{GDP_j}{GDP_{FRA}}\right) + \xi_{ij}. \end{array} \right\}. \tag{8}$$

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In this equation, $\xi_{ij} = \varepsilon_{ij} - \varepsilon_{iFRA}$ represents the error term taking into account all the disturbance factors.

4. Empirical Analysis

We consider trade and infrastructure endowments for seven WAEMU countries over the period 1996–1998. We thus have a panel structure and run an importer fixed-effect model.[17] However, since endowment variables have no time dimension here, we also run an estimation on pooled data. Let us first address some econometric issues relevant for our empirical estimations.

4.1 Some Econometric Issues

In the COMTRADE database we use, only four out of the seven WAEMU countries are reporters.[18] We can resort to mirror statistics when one of the trading partners is a reporter, but there are no mirror statistics for two non-reporter countries. Ignoring these missing observations may lead to inconsistent estimations. In addition, the omitted observations are useful since they concern South–South trade flows which are analysed in this paper. Alternatively one can use intra-WAEMU trade data to fill in the missing trade, but this yields a heterogeneity problem, since the observations of these two databases are seemingly different. However, we can combine the two data sources as follows: for the extra-regional trade flows, we use COMTRADE data and for the intra-regional trade we use WAEMU intra-trade data. We thus have a complete data set usable for estimations, and since we include a dummy variable specifying intra-WAEMU trade flows, this will correct for the heterogeneity problem. We can also estimate the missing dependent observations by using the estimated parameter obtained on observations without missing dependent variables, the so-called 'first-order method' in the econometric literature.[19] This method passes the test of unbiasedness

[17] Some recent papers (Martinez-Zarzoso and Nowak-Lehmann, 2003, Cheng and Wall, 2005 among others) suggest to run a country-pair fixed effects model and then use the estimated fixed effects in a second-stage estimation.
[18] Benin, Niger, Senegal and Togo.
[19] See, e.g., Greene (2000), Afifi and Elashoff (1996,1967), Haitovsky (1968), Anderson (1957) and Kelejian (1969).

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and appears to increase the efficiency of the estimators even if we must account for the additional variation present in the predicted values.

For the sake of comparison, we will use these three approaches by focusing on three sets of data: (1) only COMTRADE data (dropping missing dependent observations); (2) COMTRADE data for extra-regional trade and WAEMU intra-trade data for intra-regional trade; and iii) COMTRADE data and replace the missing dependent observations using the first-order method.

A second econometric issue concerns the endogeneity of the percentage of paved bilateral roads measuring the quality of the roads between two WAEMU trading partners. It is plausible that more trade flows encourage a government to build and upkeep roads, and a good road network induces more trade flows. The percentage of paved bilateral road appears thus to be an endogenous regressor. The Durbin–Wu–Hausman test of endogeneity (Davidson and Mackinnon, 1993) can be used to test for the endogeneity of this variable. The procedure is simple: include the residuals of equation (1) in the trade equation and test for the significance of the estimated parameter of these residuals. A parameter significantly different from zero suggests that $\%PR_{ij}$ is endogenous. If endogeneity is detected, we need to instrument this variable since OLS would be inconsistent. In our case, the following equation seems to be relevant to correct for the endogeneity problem:

$$\ln \%PR_{ij} = \alpha_1 \ln AREA_i + \alpha_2 \ln AREA_j + \alpha_3 \ln INFRA_{ij} + \nu_{ij} \quad (9)$$

and thus complete the final expression obtained in section 3 in a two-stage least squares approach. In equation (9), $INFRA_{ij}$ is the total length of paved road within countries i and j plus the length of paved road between these two trading partners, $AREA_i$ and $AREA_j$ being the surface area of countries i and j. We can then estimate the system including equations (8) and (9). The last step is to test for the validity of the instruments used. We resort to the Staiger and Stock (1997), which consists of regressing the instrumented variable on all the instruments and considering the F-statistic of the estimation: a value higher than 10 indicates valid instruments.

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4.2 Estimations and Results

Now, we try to quantify the impact of geographical and infrastructural disadvantages on the intra- and extra-regional trade of the WAEMU. Several data sources are mobilised: COMTRADE statistics, bilateral and internal paved roads from the WAEMU intra-trade and infrastructure database;[20] the World Development Indicators, providing many macroeconomics aggregates and lastly geographical distance from the web site of Jon Haveman.[21] Since foreign trade statistics are missing for Guinea-Bissau, the eighth country of the WAEMU, we do not include this country in the sample. The time horizon is 1996–1998.

In this section, we estimate different specifications organized in two ways: (1) according to the database used: specifications 1 and 4 use only COMTRADE data, specifications 2 and 5 use COMTRADE data for extra-regional trade and WAEMU intra-trade data for intra-regional trade, specifications 3 and 6 use the database completed by the first-order method; and (2) according to the estimation method: specifications 1, 2 and 3 use the panel method, while specifications 4, 5 and 6 use pooled data.

In all the following estimations results, a parameter with three asterisks is significant at the 1% level, that with two asterisks is significant at the 5% level and that with one asterisk is significant at the 10% level.

We start by reconsidering the results of a traditional gravity model for the sake of comparison. Then we proceed to the estimation of the Armington-based model. This latter approach shows that when geography is properly modelled, its impact on Southern countries' trade flows is more significant, a result which calls for paving road and reducing transit costs to increase South–South trade flows. Landlocked countries appear to face additional trade impediments probably due to the fact that they are the poorest countries of the union.

<u>The Traditional Gravity Model Estimations</u>

The extended gravity equation we estimate is derived from equation (3). The dependent variable is the c.i.f. import of country

[20] Source of these data: WAEMU commission. The database specifies intra-WAEMU trade flows and excludes any re-exportation flows.

[21] www.haveman.org. Alternative distance measures are provided on the CEPII website www.cepii.org.

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i from country j(ln M_{ij}).[22] The regressors are the sea distance between countries i and j (ln SD_{ij}, which is 0 if country j is a WAEMU country), the road distance between countries i and j (ln RD_{ij}, which is 0 if country i is a coastal WAEMU country and country j an OECD country), a dummy variable specifying whether country j is a French speaking country (*FRENCH*), a dummy variable specifying the WAEMU intra-regional trade (*WAEMU*), the GDP and GDP per capita of countries i and j (ln GDP_i, ln GDP_j, ln $GDPPC_i$, ln $GDPPC_j$), the real exchange rate variables (ln RER_i and ln RER_j), the percentage of paved bilateral road between country i and j(ln$\%PBR_{ij}$, for paved road between i and j), the transit distance between country i and j (ln $TRANSIT_{ij}$), the number of borders to cross from country i to j ($NBORDER_{ij}$), a dummy variable specifying a landlocked importer (LL_i), another indicating whether countries i and j are both landlocked WAEMU partners and two remoteness variables (ln REM_i and ln REM_j).[23,24]

The Durbin–Wu–Hausman test confirms the endogeneity of the variable $\%PBR_{ij}$ and calls for using instrumental variables techniques to obtain consistent estimators. To test the validity of the instruments used, we resort to the Staiger and Stock (1997) approach which validates these instruments.

In Table 4, the first three specifications include importer and time fixed effects (FE). The importer FE captures all effects specific to country i, so that any other variable indexed by i will only reflect the time dimension it contains. This is why the estimated parameters corresponding to these variables are different from what is obtained in Specification 4, 5 and 6 using pooled data. In the following comments, we focus on Specification 6 which is econometrically well-suited.

The sea and road distance parameters are negative and significant as expected. While the road distance variable yields an elasticity comparable to that obtained in most of the gravity model (close to −1), the sea distance depicts a higher negative impact on imports values of WAEMU countries: doubling this distance induces a 90% reduction of imports of a coastal importer.

[22] Evaluated in current US$ value.
[23] We consider Switzerland, Belgium and Canada as French speaking countries.
[24] Note that the variable $TRANSIT_{ij}$ is set equal to 0 if countries i and j are contiguous. If they are not contiguous, this variable is measured as the road distance from the first to the last border to be crossed by the shipped good.

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Table 4: *The Traditional Gravity Model Estimation, IV With Robust Variance Estimators*

	Panel			Pooled		
LnM_{ij}	1	2	3	4	5	6
LnSD_{ij}	−3.84***	−3.11***	−4.55***	−3.89***	−3.17***	−3.82***
LnRD_{ij}	−1.08***	−0.64***	−1.23***	−1.07***	−0.66***	−0.98***
LnGDP_i	3.17	17.05	14.45	0.93***	0.93***	0.93***
LnGDP_j	1.44***	1.34***	1.42***	1.44***	1.33***	1.44***
Ln$GDPPC_i$	−15.41	−15.45	−12.74	−1.08**	−0.53	−1.09**
Ln$GDPPC_j$	−0.08	0.15*	−0.01	−0.09	0.15*	−0.10
LnRER_i	−0.83	0.61	0.03	−1.43	−0.86	−1.45
LnRER_j	0.55***	0.53***	0.54**	0.55***	0.51***	0.56***
FRENCH	1.26***	1.36***	1.22***	1.25***	1.35***	1.25***
WAEMU	−27.25***	−21.24***	−34.22***	−27.77***	−21.74***	−27.13***
$NBORDER_{ij}$	0.42	0.02	0.45	0.43	0.04	0.38
LL_i				0.23	0.23	0.20
LL_i	−2.02***	−1.75***	−2.40***	−2.04***	−1.75***	−2.03***
LnREM_i	59.97	63.11	56.88	1.74	091	1.65
LnREM_j	1.18**	0.53	1.88***	1.16**	0.58	1.09***
Ln%PR_{ij}	1.76***	1.17***	2.77***	1.78***	1.20***	1.61***
Ln$TRANSIT_{ij}$	−0.21**	−0.26**	−0.34***	−0.22*	−0.26***	−0.21**
CONST	495.39	351.12	464.48	40.74***	21.94**	39.43***
R^2	0.23	0.11	0.16	0.59	0.59	0.59
P	0.00	0.00	0.00	0.00	0.00	0.00
N	596	640	640	596	640	640

$M^*_{ij} = 2^{-3.82}\,\text{Dist}_{ij}^{-3.82} = 0.07M_{ij}$, hence about 90% of trade reduction. For a landlocked WAEMU country, we have to add to this effect the inland distance crossed by the shipped good. Limao and Venables (2001) also differentiate between sea and land distance and obtain higher road distance negative effects, but they use very specific trade flows (40-foot containers from Baltimore to different destinations).

The GDP variables yield significant parameter estimates, similar to those obtained by Soloaga and Winters (2001),Martinez-Zarzoso and Nowak-Lehmann (2003) and Head (2003). The GDP import elasticity of country *i* appears to be below unity, while that of the exporter is above unity. This asymmetry suggests that WAEMU

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countries enjoying an economic expansion manage to domestically supply some of the goods they consume, while exporters strive to conquer foreign markets. The negative sign of the per-capita GDP import elasticity tends to confirm our claim of local supply of consumers' needs: wealthier consumers can find locally the products they desire since the economic expansion makes them locally available. Note that other papers focusing on developing or transition countries yield such a negative parameter for the per-capita GDP (Disdier and Mayer 2003,Montenegro and Soto 2000).

The real exchange rate variable of the importer is not significant while that of the exporter depicts a positive elasticity. To understand the meaning of this sign, we have to refer to the definition of this variable: $RER_j = e \times \Pi_{US}/\Pi_j$, where e is the value of one US dollar evaluated in the currency of country j. Thus, an increase in RER_j suggests that country j is more competitive than the US, hence an increase of imports from this country.

Sharing French language seems to have a positive impact on trade flows and the intra-regional trade of the WAEMU countries (measured by the dummy variable WAEMU) appears to be very low with regard to the extra-regional trade flows. Being a French-speaking exporter induces 3.5 times more import demand from WAEMU countries. Since the Armington-based model is supposed to capture any 'colonisation effect' of France, we will assess whether this result vanishes or not. The parameter estimates of the number of borders to be crossed by the imported goods, the landlockness and the remoteness of the importer are not statistically significant. However, two landlocked WAEMU countries (variable LL_{ij}) appear to trade on average about 90% less than two other trading partners. The positive impact of the remoteness of the exporters probably reflects the external openness of WAEMU countries: their main suppliers are OECD countries regardless of distance.

Now we turn to the two original variables of our paper: the percentage of paved bilateral road and the transit distance. It appears that a 10% increase of the percentage of paved bilateral road induces a 17% increase in trade, the panel specification even suggesting a 30% trade increase.[25] The negative and significant

[25] If we focus only on the percentage of paved bilateral road in Specification 6 we have $LnM_{ij} = 1.61 \ln \%PR_{ij}$ which yields $M_{ij} = (\%PR_{ij})^{1.61}$, so that a 10% increase of this variable implies: $M_{ij}* = 1.1^{1.61} (\%PR_{ij})^{1.61} = 1.17M_{ij}$.

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parameter estimate of the transit variable shows that crossing a transit country induces additional trade impediments: crossing a transit territory accounts for 4% of trade costs.[26]

In sum, the traditional gravity model estimations provide three interesting results: (1) the positive impact of the percentage of paved bilateral road on WAEMU countries trade flows; (2) the negative impact of the presence of a transit country within the WAEMU; and (3) the additional impediments faced by landlocked WAEMU countries.

How are these results impacted by the nature of the shipped products is an interesting issue that can be partially addressed here.[27] The COMTRADE database provides 2-digit trade flows statistics and we can use these disaggregated bilateral imports as the dependent variables. There are 99 2-digit product categories and for most of them, the import flows of WAEMU countries are very small, and can therefore not yield robust estimations. To address this problem, we group these products into 14 industries following Fontagné *et al.*, (1997). For these product-specific estimations, it is not realistic to use GDP deflator as a price proxy. Besides, we do not fill in the missing observations for the non-reporter countries. We use a Tobit estimation to take into account the low trade values censored to zero.[28]

These disaggregated estimations provide interesting results illustrating the importance of geography in intra- and extra-WAEMU trade. The sea-distance reduction effect is unsurprisingly high for heavy products (agriculture, forestry, mining and metal product) and commodities imported by WAEMU countries (food and chemicals), while the road distance parameter estimates are positive for Motor vehicles; this unusual distance effect may be due to the fact that countries with a wider road network are more likely to import such products. The colonial ties (captured by the sharing of French language) seem to matter more for non-agricultural raw materials and for machinery. The bilateral geographical variables do not yield significant results, except for the number of borders which yields a significant negative parameter for the leather,

[26] In Specification 6, trade costs are due to sea distance (76%), road distance (20%) and transit distance (4%).
[27] This product analysis is only indicative as a result of a lack of information regarding the specific way of shipment of each product.
[28] These estimations are available upon request.

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textile and non-electrical industries. Since these industries are more likely to be present within the union, this may reveal that borders continue to hinder trade within the union.

The Armington-based Model Estimations

Now, we turn to the testable form of the theoretical model derived in Section 3, which is the main contribution of this paper. The dependent variable is relative imports as described in section 3 and the regressors are those included in this final formulation expressed in equation (8). Here again, the Durbin–Wu–Hausman test confirms the endogeneity of the variable $\%PR_{ij}$ and instrumental variables method is required. The Staiger and Stock (1997) procedure confirms the validity of the instruments used.

In the following comments, we focus on specification 6 which takes into account all the econometric problems raised by the data we use.

Table 5 shows that the Armington-based model yields a lower sea distance effect and a higher road distance effect compared with the traditional gravity model, a result which confirms that this approach helps to better evaluate the impact on WAEMU countries trade of geographical impediments and infrastructure endowments. The negative and significant parameter of the relative GDP deflator (Π_j/Π_{FRA}) is an interesting result which suggests a substitution of French import to any other importer with a higher GDP deflator. Indeed, Specification 6 indicates that if an exporter price doubles relative to the French GDP deflator, the importer reduces its imports from this country by 50% in favour of France.[29] The relative real exchange rate does not yield a significant effect, a result which confirms our claim of a weak impact of exchange rates because of the fixed parity between the CFA franc and the French franc. The positive and significant effect of the relative GDP suggests that country i more likely trades with countries economically more efficient than France.

[29] If we focus only on the relative GDP deflator variable in Specification 6, we have $\ln(E_{ij}/E_{iFRA}) = -1.05 \ln(\Pi_j/\Pi_{FR})$ which yields $(E_{ij}/E_{iFRA}) = (\Pi_j/\Pi_{FR})^{-1.05}$, so that a doubling of the GDP deflator of country j relative to that of France implies: $(E_{ij}/E_{iFRA})^* = 2^{-1.05}(\Pi_j/\Pi_{FR})^{-1.05} = 0.48\,(E_{ij}/E_{iFRA})$, hence about 50% of the imports of country i from country j are reduced in favour of increased imports of country i from France.

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Table 5: *The Armington-based model estimations, IV with robust variance estimators*

	Panel			Pooled		
$\mathrm{Ln}(E_{ij}/E_{iFRA})$	1	2	3	4	5	6
$\mathrm{Ln}(SD_{ij}/SD_{iFR})$	−3.22***	−3.29***	−3.18***	−3.26***	−3.29***	−3.18***
$\mathrm{Ln}(RD_{ij}/RD_{iFRA})$	−1.19***	−0.90***	−1.05***	−1.24***	−0.94***	−1.13***
$\mathrm{Ln}(\Pi_j/\Pi_{FR})$	−1.02***	−0.77***	−1.00***	−1.06***	−0.81***	−1.05***
$\mathrm{Ln}(RER_j/RER_{FRA})$	0.27	0.36*	0.30	0.23	0.30*	0.24
$\mathrm{Ln}(GDP_j/GDP_{FRA})$	1.33***	1.35***	1.33***	1.34***	1.36***	1.34***
$\mathrm{NBORDER}_{ij}$	0.53*	0.24	0.43*	0.68*	0.33	0.61**
FRENCH	1.05***	1.09***	1.05***	1.05***	1.08***	1.05***
WAEMU	−22.06***	−22.06***	−21.88***	−22.77***	−22.26***	−22.08***
LL_i				1.40**	1.89***	1.36
LL_{ij}	−2.39***	−2.71***	−2.33***	−2.54***	−2.78***	−2.49***
LnREM_i	−2.42	2.43	−3.01	0.19	−0.25	0.16
LnREM_j	0.64	0.68*	0.61	0.68	0.71**	0.61
$\mathrm{Ln\%PR}_{ij}$	1.90***	1.33***	1.75***	2.06***	1.42***	1.87***
$\mathrm{LnTRANSIT}_{ij}$	−0.22**	−0.24***	−0.21***	−0.27**	−0.26***	−0.27***
CONST	−18.76	20.88	−23.84	1.69	−1.73	1.30
R^2	0.49	0.44	0.53	0.53	0.55	0.55
P	0.00	0.00	0.00	0.00	0.00	0.00
N	573	617	617	573	617	617

Here, the border variable yields a surprising positive and significant effect, which probably reflects trade flows between the three leading members of WAEMU: Benin, Cote d'Ivoire and Senegal. Indeed, as we can see from Figure 1, five borders separate Benin from Senegal, three separate Benin from Cote d'Ivoire and two separate Cote d'Ivoire from Senegal. The common language effect decreases from 3.5 to 2.8 times more trade between French-speaking partners, indicating a correction of the French colonisation effect over these developing countries. WAEMU intra-trade indicator here again indicates a very low intra-regional trade with regard to their external openness. In addition, WAEMU landlocked countries appear to trade 92% less than two other trading partners. The remoteness variables are not statistically significant.

Specification 6 points to the positive return of paved bilateral roads on trade flows. For the inter-state roads not totally paved, we can use

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the elasticity of this variable to compute the amount of extra import flows created when the percentage of paved road is completed to 100%.[30] The results are presented in Table A3 in the Appendix.

Not surprisingly, we find that the lower the percentage of paved bilateral road, the higher the impact of this infrastructure improvement on import flows. The most concerned trading partners are Mali and Senegal. Indeed, for the year 1998, the simulation indicates that improving the inter-state road paving between these partners from 31% to 100% could induce four times more trade. This is a serious issue: Senegal is the second largest economy, and its remoteness from the other members tends to weaken the union economy. Moreover, this remoteness also affects trade flows between Senegal and Cote d'Ivoire. We find that a 100% pavement of the road between these two countries could double trade flows between them. If we take into account all the extra trade created by this '100% paving of inter-state roads' infrastructure policy, trade flows in this region are 3.19 times higher.[31] This is an important trade potential regarding the low intra-regional trade of the union.

The Armington-based model also points to the additional trade cost due to transit distance measured. The negative and statistically significant effect of this variable confirms the idea that crossing a transit country yields extra trade costs independently of trade costs induced by the distance between the exporting and importing countries. Doubling this variable induces 17% less trade, an effect which adds to the traditional distance effect. This variable thus proves to be a good proxy for internal geographical impediments of transit countries.

To complete our analysis, we also consider two additional factors: the export diversification/concentration and the non-linear impact of paved bilateral road.[32] First we analyse the impact of the export concentration of WAEMU countries on the low level of trade observed between them. Indeed, if these countries export only agricultural raw materials dedicated to developed countries,

[30] One can claim an over-estimation of trade flows when using this elasticity of the pavement variable which takes into account extra- and intra-regional trade flows to simulate intra-regional trade flows. However in the specifications, we include an intra-WAEMU trade dummy variable which captures all effects specific to intra- but also extra-trade. Thus, using this elasticity for simulation is relevant.

[31] We obtain 3.05 times more import flows when using the panel specification (Specification 3 of Table 5).

[32] These estimations can be obtained on request.

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their bilateral trade will necessarily be low.[33] To assess this effect, we add a Herfindhal sectorial concentration index of the most exported product of each WAEMU country using ITC Trade Performance Index.[34] The estimations yield statistically non-significant parameters for this variable indicating that the export concentration has no statistical impact on intra-WAMEU trade flows. Second, we explore a non-linear impact of the percentage of paved bilateral roads on trade flows using the term $\ln\%PR_{ij} + (\ln\%PR_{ij})^2$. The estimations yield no statistically significant parameters indicating that introducing only the variable $\ln\%PR_{ij}$ is the appropriate way to assess the impact of this variable on trade flows.

5. Conclusion

In this paper, we aimed at analysing the impact of geography on South–South trade, starting with the puzzle indicating a global disadvantage faced by landlocked countries, and particularly developing ones. We focused on the integrated countries of the West African Economic and Monetary Union for which suitable data for such an analysis are available.

The traditional gravity model estimates confirmed the statistically significant effect of sea distance, road distance and GDP of the trading partners on trade flows. Increasing the percentage of paved bilateral road leads to higher trade flows. Shipping goods through a transit country proves to yield additional trade costs, accounting for 4% of the trade costs. Colonial ties seem to matter for non-agricultural raw materials and machinery trade. Second, it appears that the leather, textile and non-electrical machinery goods, which mainly concern intra-regional trade, face strong border impediments revealing a weakness of the integration process.

The estimations of the Armington-based model emphasise the role of geographical determinants. First, the paved bilateral road return on trade flows is confirmed and reinforced. If all the interstate roads were paved, the countries would trade three times more than is observed. We can now answer our initial question, as to whether there is an untapped South–South trade potential,

[33] We are indebted to Sébastien Jean and Thierry Mayer for suggesting this explanation.
[34] International Trade Center UNCTAD/WTO, www.intracen.org.

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given remoteness, economic size and landlockness of the countries in the region. The answer is yes, there is an untapped potential calling for road paving projects in the WAEMU and probably in many other developing regional integration areas. Second, transit distance proves to be an additional impediment to trade, indicating that the internal geography of the transit countries matters. Finally, WAEMU landlocked partners appear to trade 92% less than two other partners, a result which confirms the further disadvantages faced by landlocked countries in the developing world.

Appendix

Tables A1–A3

Table A1: *The Disadvantage of Landlocked Countries: A Gravity Model Approach (TOBIT Estimations)*

$LnExport98_{ij}$	1	2	3	4	5
$LnDIST_{ij}$	−1.21***	−1.26***	−1.24***	−1.24***	−1.23***
$LnGDP_i$	1.16***	1.15***	1.15***	1.15***	1.16***
$LnGDP_j$	0.85***	0.83***	0.83***	0.83***	0.85***
$LnGDPPC_i$	0.24***	0.16***	0.17***	0.17***	0.17***
$LnGDPPC_j$	0.16***	0.06**	0.07**	0.07**	0.07**
$CONTIG_{ij}$	1.08***	0.89***	0.85***	0.88***	0.84***
$LANG_{ij}$	0.85***	0.82***	0.82***	0.81***	0.84***
1LLE	−0.32***	−0.40***	−0.39***	−0.39***	
1LLNE	−0.50***	−0.41***	−0.42***	−0.41***	
2LLNE	1.15*		1.07*		
1AFR		−0.93***	−0.93***	−0.94***	−0.95***
2AFR			0.16	0.18	0.20
CONST	−6.26***	−3.79***	−4.01***	−3.99***	−4.47***
Pseudo-R^2	0.15	0.16	0.16	0.16	0.15
P-value	0.00	0.00	0.00	0.00	0.00
N	7,825	7,825	7,825	7,825	7,825

DIST: geographical distance; GDPPC: GDP per capita; CONTIG: contiguity; LANG: common language; 1LLE: one European landlocked partner; 1LLNE: one non-European landlocked partner; 2LLNE: two non-European landlocked partners; 1AFR: one African partner; and 2AFR: two African partners.

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Table A2: *Bilateral Paved Road within WAEMU*

Partners	Road Distance(km)	% Paved
Benin–Burkina Faso	1,022	55
Benin–Cote d'Ivoire	568	100
Benin–Mali	1,552	100
Benin–Niger	1,041	100
Benin–Senegal	3,038	69
Benin–Togo	189	100
Burkina Faso–Cote d'Ivoire	1,176	100
Burkina Faso–Mali	610	100
Burkina Faso–Niger	537	100
Burkina Faso–Senegal	2,016	57
Burkina Faso–Togo	970	100
Cote d'Ivoire–Mali	1,184	100
Cote d'Ivoire–Niger	1,609	100
Cote d'Ivoire–Senegal	2,634	62
Cote d'Ivoire–Togo	588	100
Mali–Niger	1,423	80
Mali–Senegal	1,486	31
Mali–Togo	1,500	100
Niger–Senegal	2,909	65
Niger–Togo	1,507	100
Senegal–Togo	2,986	68

Sources: WAEMU commission

Table A3: *Extra 1998 Import Flows When the % of Paved Bilateral Roads is Raised to 100*[a]

Country *i*	Country *j*	% PR_{ij}	ΔM_{ij}	M_{ij}	$\Delta M_{ij}/M_{ij}$ (%)
BEN	BFA	55	1,432	936	153
BEN	SEN	69	7,347	8,745	84
BFA	BEN	55	226	174	153
BFA	SEN	57	4,742	3,362	141

(*continued on next page*)

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Table A3 (*continued*)

Country *i*	Country *j*	% PR_{ij}	ΔM_{ij}	M_{ij}	$\Delta M_{ij}/M_{ij}$ (%)
CIV	SEN	62	16,294	14,217	115
MLI	NER	80	249	533	47
MLI	SEN	31	123,831	29,751	416
NER	MLI	80	505	1,081	47
NER	SEN	65	864	858	101
SEN	BEN	69	121	144	84
SEN	BFA	57	83	59	141
SEN	CIV	62	28,147	24,558	115
SEN	MLI	31	12,599	3,027	416
SEN	NER	65	11	11	100
SEN	TGO	68	104	119	88
TGO	SEN	68	2,950	3,352	88
Total		61	199,548	90,927	219

Sources: WAEMU Commission and our calculations.
Units are 1,000$
[a]In fact, we have $\Delta M_{ij} = 1.87 \times \Delta\%PR_{ij}/\%PR_{ij} \times M_{ij}$, using the estimated parameter of $\%PR_{ij}$ in specification 6 of Table 5.

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