South - South Trade: Geography matters

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Abstract

Intra-subsaharan African trade appears to be very low, 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 potentials. 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 of the West African Economic and Monetary Union, which have been involved in an integration process since their early days of independence. We derive and estimate an Armington-based model in order to evaluate the impact of geographical impediments on bilateral trade flows within this region. Since some of the countries in concern are not reporting countries, we use the "first-order" method designed by Kelejian (1969) to fill in the missing trade flows. We alternatively and simultaneously use COMTRADE data and West African Economic and Monetary Union data to perform these estimations.

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1 The Puzzle

In a recent paper, Sachs (2001) pointed out that "since sea-navigable regions are generally richer than landlocked regions, regions that are both temperate and easily accessible to sea-based trade almost everywhere have achieved a very high measure of economic development. Tropical and landlocked regions, by contrast, are among the very poorest in the world". This statement evokes many issues linked to geographical disadvantages. Indeed, a glance at the world economy points to developing landlocked areas loosely integrated in international trade flows, as can be seen in Table 1. The export to GDP ratio for developing landlocked countries was 20%, while for developed landlocked countries it was 50% in 2000. Turning to non-landlocked countries, this ratio was respectively 40% and 20% for developing and developed countries, which suggests that landlocked developing countries are less involved in international trade than landlocked developed countries.

We estimated a gravity model with a sample of 134 countries[1] for the year 1992 and the results confirm this poor performance of southern countries in world economy, as can be seen in Table 2. Controlling for distance, GDP, GDP per capita, contiguity and common language, it appears that European landlocked countries[2] trade nearly twice as much as the other countries in the world while non-European landlocked countries trade 40% less (cf. column 1 in Table 2). Besides, it appears that two non-European landlocked countries trade 80% less than two other pair of trading partners. When focusing on African countries, we can see (column 3 in Table 2) that an African country trade 40% less than another country and two African countries trade 90% less than another pair of trading partners. These results evoke the exacerbating weakness of South-South trade.

Another prominent fact is the evidence that South-South trade agreements have had limited benefits (Greenaway & Milner, 1990); intra-regional trade (particularly subsaharan African countries) remains very low. This feature is also apparent in the West African Economic and Monetary Union[3] (WAEMU), where the share of intra-regional trade in total trade did not exceed 3% during the 1990s, despite an openness rate of 70%! These countries account less in world trade but trade more with developed than developing countries.

This evidence raises three issues:

1) What is the magnitude of untapped trade potentials in the South?

2) What responsibility bears geography?

3) To what extent does the lack of transportation infrastructures hinder trade?

Answering these two latter questions will point out to what extent geography[4] matters in southern countries regional trade.

[1] The sample we use is unbalanced.

[2] In our sample, these countries are: Austria, Switzerland, Czech Republic and Hungary

[3] This Union consists of eight countries: Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo (See Figure 1).

[4] By geography, we mean physical geography as well as infrastructures endowements. See

As far as the first issue is concerned, Foroutan & Pritchett (1993) estimated a traditional gravity model with subsaharan African specific variables and claimed that there was no untapped potential in intra-regional trade. But this result is sensitive to the sample of countries considered as the reference group. Indeed, Fontagné, Pajot & Pasteels (2002) showed that there is a strong non-linearity in the impact of income per capita on trade, leading to biased elasticities obtained in a sample with heterogeneous countries.

Amjadi & Yeats (1995) adressed the second issue. Examining net freight and insurance payments from the balance of paiement statistics from IMF, they argued that the relative low level of subsaharan African exports was essentially due to high transport costs. They noticed that, between 1990 and 1991, the net freight and insurance bill of this region represented 15% of the value of their exports, compared to less than 6% for all the developing countries.

Limao & Venables (2000) suggest a significant impact of transportation infrastructure quality on transport costs and consequently, on trade flows. They found that poor infrastructure accounts for 40% of predicted transport costs for coastal countries and 60% for landlocked countries, and that the relatively low level of African trade flows was largely due to poor infrastructure.

These studies deserve credit for giving scientifically-based answers to such contentious questions, but they are not based on an explicit model taking into account the geographical and infrastructural features which seem to be sizeable barriers to trade in subsaharan Africa. Addressing properly this issue should quantify the importance of geographical and infrastructural disadvantages. Geography matters in South-South trade and we should include this aspect when estimating the trade potential.

The purpose of this paper is to assess the importance of subsaharan African countries' geographical and infrastructural disadvantages by focusing on their intra and extra regional trade flows. We restrict our work to the West African Economic and Monetary Union countries for which data are available on intra-regional trade and infrastructures, and also include their trade flows with OECD countries in order to take into account their impressive openness rate.

The remainder of the paper proceeds as follows: the data used and the stylized facts on geographical and infrastructural disadvantages of the WAEMU are detailed in Section 2. An Armington-based model for the determination of trade flows is developed in section 3. In Section 4, we discuss the econometrics issues raised by the data. In section 5, we first estimate a traditional gravity model for the sake of comparison and also carry out product-specific estimations to see to what extent the imported product matters, then estimate the Armington-based model we derived. The last section concludes the paper.

Henderson, Shalizi & Venables (2001) for review of the literature and Limao & Venables (2000) for a tentative of measure of the impact of infrastructure and geographical location of a country on transport costs.

2 Data and Stylized Facts

In this study, several data sources are mobilized: COMTRADE statistics, bilateral and internal paved roads from the WAEMU trade and infrastructure statistics database[5]; the World Development Indicators, providing many macroeconomics aggregates, the Center for International Data at UC Davis web site[6] for the bilateral trade used in Table 2, and lastly geographical distance from the web site of Jon Haveman[7]. Since foreign trade statistics are missing for Guinea-Bissau, the eighth country of the WAEMU, we did not include this country in the sample. We only focus on the period 1996-1998. In the following of this section, we will examine the geographical and infrastructural features in this region.

Figure 1: The West African Economic and Monetary Union

[5] Source of these data: WAEMU comission.

[6] www.internationaldata.org

[7] www.haveman.org

2.1 Road Infrastructures

The West African Economic and Monetary Union comprises eight countries: five coastal (Benin, Côte d'Ivoire, Guinea-Bissau, Senegal and Togo) and three landlocked (Burkina Faso, Mali and Niger). More than three quarters of this area is located in the Sahel and two coastal countries (Senegal and Guinea-Bissau) are located far from the other members (see the map above).

Roads are the main transportation infrastructures 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 unequally distributed among members and it is integrated to the whole West African roads network, which comprises three types of roads: the coastal roads linking coastal countries, the corridors linking landlocked countries to the sea, and the trans-sahel road from the Niger-Chad border to Senegal.

The coastal countries representing 20% of the Union surface area possess more than 70% of the Union roads. Côte d'Ivoire is by far the best endowed country in road infrastructure, concentrating about half of the whole Union network and more than a quarter of paved roads (see Table 3).

The average road density of the Union is about 5.9 km per 100 km^2. The Inter-State[9] roads network is 13,202 km long, of which 80% are paved. But there are almost no paved roads between Senegal and Mali, which pratically isolates Senegal and Guinea Bissau from the other members of the Union in terms of land transport. In addition, some parts of these inter-state roads are not usable all over the year since they are unpaved or in poor condition.

2.2 Border Infrastructures

The Union members have signed two multilateral conventions[10] to regulate and facilitate road transport and transit across borders. Despite these arrangements, border infrastructures have been judged too underdeveloped to allow the development of intra-regional traffic. A recent survey [11] funded by the WAEMU Commission provided information on custom offices (suitable or not, joined or not, adjacent or not), weighbridges, radios, documentation on tax rate, typewriters, parking and stocking places.

For an overview of these border infrastructure endowments of the Union, we built a score combining all the information available on each border equipment. The method is simple: at a border, if the two customs offices possesses a given item of equipment or characteristic, the score is 2. If only one has it, the score is 1, and 0 if no one possesses it. Then these scores add up to a percentage on a scale of border equipments, presented in Table 4.

[8] Estimation of the transport department of WAEMU commission in 2001.

[9] Highways between countries

[10] Referring to the document "Etude sur la facilitation du transport et du transit routier Inter-Etats" (1998), WAEMU Commission.

[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 Comission.

On the basis of this scoring, it appears that the borders Côte d'Ivoire-Mali, Togo-Burkina Faso, Burkina Faso-Niger and Burkina Faso-Mali are the best endowed. In addition, these countries are connected with paved roads. Table 4 also reveals an additional source of remoteness (apart from geographical distances) of Senegal and Guinea-Bissau[12] from the other members of the Union. Indeed, the score of the Mali-Senegal border is the lowest, and in addition only 31%[13] 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.

This border score is a very useful variable but since we do not have an evaluation for all the borders within the WAEMU, we cannot use it in the empirical estimations we will perform.

2.3 Geographical features

When comparing the geographical and road bilateral distances between WAEMU countries[14], road distances are on average 30% longer than geographical distance, the averages being 1,503 km for the road distance and 1,128 for the geographical distance, with a standard deviation of around 900 km.

Another geographical feature in this area is the fact that the three landlocked countries share at least four borders with the other members, when this figure is on average two for the coastal countries. This suggests that landlocked countries are at the geographical center of the Union. Contrasting with the traditional economic geography argument, GDP per capita of these countries is lower than that of the peripheral coastal ones, a fact that indicates less economic activities in the geographical center than at the "periphery".

In Table 5, we focus on pairs of countries i and j from the WAEMU. The first column indicates wether country i is landlocked or not. The second column indicates wether countries i and j are contiguous. The third and the fourth columns report the ratios $\frac{GDP_i}{GDP_i+GDP_j}$ and $\frac{GDP_i \ per\ capita}{(GDP_i+GDP_j)\ per\ capita}$. These figures show that the bilateral share of GDP and GDP per capita of non-landlocked countries are higher than those of landlocked ones, which brings out a particular core-periphery feature between coastal and landlocked countries of the WAEMU. This is in line with the findings of Redding & Venables (2001), whereby the more remote a country is from the economic center, the lower is its income per capita.

Transport costs in southern countries appear to be increased by geographical and infrastructural landlocking. Not only are these countries' endowments in transportation infrastructure globally low and some of the paved roads decaying because of no or insufficient upkeep, but also the lorries used for merchandise transportation are very old, overloaded and consequently generate high maintenance costs. In addition, the impressive number of bilateral and multilateral transit arrangements in these areas are not always effective, so that crossing

[12] Note that these two countries are located at the far west of the Union (see the map above).
[13] Note for the sake of comparison that within the Union, 61% of the inter-state roads are paved on average.
[14] The distances are measured between capital cities.

borders appears to be very costly because of more customs and administrative checking , more distance to travel through, more police harassment through the journey and so on. These impediments can be tremendously exacerbated if the transit country's physical geography is cumbersome.

In the following, we will build a bilateral trade model in order to analyze the intra and extra trade of these southern countries.

3 The model

The gravity model is one of the most frequently used tools for the analysis of international trade flows. It has been considered as the "natural companion" of monopolistic competition models which assume a taste for variety by consumers. But taste for variety is effective if consumers have a seemingly high income, which is not the case in developing countries. With reference to this, Hummels & Levinsohn (1995), using a sample including developed and developing countries together, noticed that the estimations were consistent with the two types of countries, that is, gravity works even when the monopolistic competition model is an implausible explanation for trade flows. However, Deardoff (1995) demonstrated that gravity models also fit a traditional perfectly competitive framework.

In this section, we set up a model derived from the Armington assumption and obtain a structural model that can be estimated, taking into account the geographical and infrastructural disadvantages.

Let us consider a two-regions world: South and North (here, WAEMU and OECD). We focus on the southern countries' imports flows. Southern countries are denoted by i, $i = 1, ..., I$ and Northern countries are denoted by k, $k = 1, ..., K$ each country producing a specific good. The goods are thus differentiated by their origin. Let us assume a constant and non-unit elasticity of substitution to consume each of these goods. The utility function of the representative consumer in country i is represented by:

$$U_i = \left(\sum_{j=1}^{I+K} M_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where M_{ij} is import of country i[15] from country j. In order to simplify, we assume that the representative consumer uses all his income for imported goods, so that his budget constraint is:

[15] 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 bilatreral southern trade flows. Another assumption is that σ is the same for all the countries.

$$Y_i = \sum_{j=1}^{I+K} P_{ij} M_{ij} = \sum_{j=1}^{I+K} P_j \tau_{ij} M_{ij} \tag{2}$$

where τ_{ij} is an iceberg transport cost between country i and j. The consumer program is then to maximize his utility function with respect to his budget constraint. From this maximization problem, we derive the first order conditions and combine them to have the following equation:

$$P_{ij} M_{ij} = \tau_{ij}^{1-\sigma} \left(\frac{P_j}{\left(\sum_{j=1}^{I+K} (P_j \tau_{ij})^{1-\sigma} \right)^{\frac{1}{1-\sigma}}} \right)^{1-\sigma} Y_i \tag{3}$$

which indicates a gravity type relation: the import value of country i from country j depends on the trade cost between these countries (τ_{ij}), the income of country i (Y_i) and a price term including characteristics of country j and those of other trading partners. We can simplify it by re-expressing equation (3) relative to a reference country, so as to cancel out the price term[16]. We will use here France as reference country because of its historical ties West African countries. Doing so will also correct for any "colonization effect".

Defining trade values as $P_{ij} M_{ij} = E_{ij}$, this leads to:

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

The left hand side of equation (4) represent in fact country i's import from country j relatively to country i import from France. The following point is then to state a relevant transport cost and price function. How to measure the geographical impediments? An innovating point in this paper is to proceed from the figure below.

[16] This method has been used by Head & Mayer (2000).

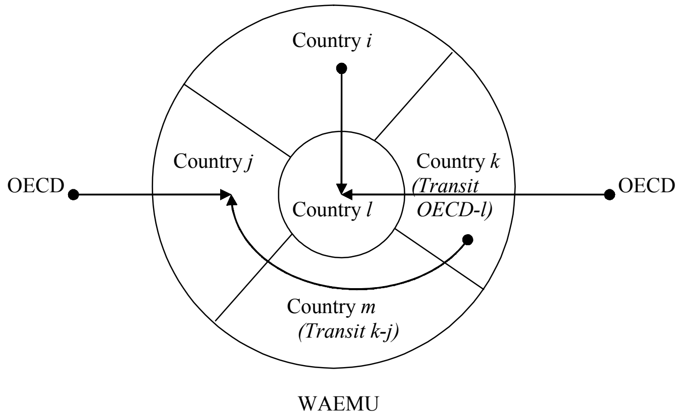

Figure 2: Intra and Extra import flows for WAEMU countries

This figure shows import patterns for two southern countries: a coastal country (j) and a landlocked country (l). In its extra-regional trade, country j faces only sea distance, but in its intra-regional trade, it faces road distances but also extra-borders impediments when there is a transit country to be crossed. Country l (the landlocked one) faces sea distance and an "extra transit3 distance in its extra-regional trade, and in its intra-regional trade, it faces raod and extra borders impediments in its extra-regional trade.

Since we deal here with intra and extra regional trade, it is convenient to pay more attention to transit countries in order to focus on the real impediments due to inland trade costs.

In a regional context, geographical impediments between two trading partners that are separated by a transit country can be due to three factors:

i) a border factor (there are extra borders to cross), which can be proxied by the number of borders to be crossed by the shipped good,

ii) a distance factor (there is an extra distance to be covered by shipped goods), which can be approximated by the road distance from the first border to the last border crossed by the imported good,

iii) an infrastructure factor (the quality of the extra road distance mattering), which can be estimated by the percentage of paved roads between the two trading partners.

These extra impediments can considerably affect trade flows in developing areas. In the trade with OECD countries, the journey between a northern and a southern trading partners can be evaluated as follows:

i) the sea distance for a coastal importer,

ii) the average sea distance (δ_i) over all the southern coastal countries for a landlocked importer i,

iii) the average road distance (κ_i) over all the southern coastal countries for a landlocked importer i.

This computation for landlocked countries is justified by the fact that we do not know, from the database we use, which coastal country is used as transit country, so that a better way to randomize the transit country is to use average distance aver all the possible transit countries. In order to take into account these points, we postulate for the following ad-hoc non-linear transport costs function:

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

SD_{ij} represents sea distance between countries i and j, RD_{ij} represents road distance between countries i and j, as described above, ε_{ij} is a disturbance term coming from unobservable sources of trade costs,ε_{ij} is a disturbance term coming from unobservable sources of trade costs and V_{ij} is defined as follows:

$V_{ij} = e^{\beta_1 FRENCH + \beta_2 WAEMU} \times \%PR_{ij}^{\gamma_1} \times TRANSIT_{ij}^{\gamma_2} \times e^{\gamma_3 NBORDER_{ij}}$ if $j \in WAEMU$,

$V_{ij} = 1$ if $j \in OECD$.

$FRENCH$ is a dummy variable specifying 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 by the imported good.

This transport cost function suggests that transport costs are non-linearily affected by sea and road distances between the two trading partners, and the geographical and infrastructural caracteristics of the importer located in the South. For the relative price function, we use the GDP deflator (labelled as Π) of the exporter relatively to the GDP deflator of France, adjusted by a factor η. Using these specifications in equation 4 yields:

$$\frac{E_{ij}}{E_{iFRA}} = \left(\frac{SD_{ij}^{\alpha_1}}{SD_{iFRA}^{\alpha_1}} \frac{RD_{ij}^{\alpha_2}}{RD_{iFRA}^{\alpha_2}} \frac{V_{ij}}{V_{iFRA}} \right)^{1-\sigma} \left(\frac{\Pi_j^{\eta}}{\Pi_{FRA}^{\eta}} \right)^{1-\sigma} \frac{e^{\varepsilon_{ij}}}{e^{\varepsilon_{iFRA}}}. \tag{6}$$

We can notice that $V_{iFRA} = 1$ as defined above. The relative road distance[17] can be simplified as follows:

i) when i is a coastal country and j is an OECD country, $RD_{ij} = 1$ hence $\frac{RD_{ij}^{\alpha_2}}{RD_{iFRA}^{\alpha_2}} = 1$,

ii) when i is a landlocked country and j is an OECD country, $\frac{RD_{ij}^{\alpha_2}}{RD_{iFRA}^{\alpha_2}} = \kappa_i^{\alpha_2}$,

iii) when i is a coastal country and j is a WAEMU country, $\frac{RD_{ij}^{\alpha_2}}{RD_{iFRA}^{\alpha_2}} = RD_{ij}^{\alpha_2}$,

iv) when i is a landlocked country and j is a WAEMU country, $\frac{RD_{ij}^{\alpha_2}}{RD_{iFRA}^{\alpha_2}} = RD_{ij}^{\alpha_2}$.

Finally, we have to estimate this version of the structural equation explaining relative bilateral imports by geographical, infrastructural and relative prices variables:

$$\begin{aligned}\ln\left(\frac{E_{ij}}{E_{iFRA}}\right) &= (1-\sigma)\,\alpha_1 \ln\left(\frac{SD_{ij}}{SD_{iFRA}}\right) + (1-\sigma)\,\alpha_2 \ln\frac{RD_{ij}}{RD_{iFRA}} \\ &+ (1-\sigma)\,\beta_1 FRENCH + (1-\sigma)\,\beta_2 WAEMU \\ &+ (1-\sigma)\,\gamma_1 \ln \%PR_{ij} + (1-\sigma)\,\gamma_2 \ln TRANSIT_{ij} \\ &+ (1-\sigma)\,\gamma_3 NBORDER_{ij} + (1-\sigma)\,\eta \ln\left(\frac{\Pi_j}{\Pi_{FRA}}\right) + \xi_{ij}.\end{aligned}$$

In this equation, $\xi_{ij} = \varepsilon_{ij} - \varepsilon_{iFRA}$.

4 Econometric issues

Firstable, let us mention that we do not perform panel data estimations since the time horizon is short (three years) and the weighted least squares yields similar results. We address in this section three econometric issues relevant in our empirical estimations: missing dependent observations, censored regressions and instrumental variables estimations.

4.1 Missing dependent observations

In the empirical part of this paper, we used COMTRADE data. One problem that arises is that only four[18] of the seven WAEMU countries are reporter countries at the UN trade statistics. We can use mirors statistics only when one of the trading partners is reporter. How to deal with these missing observations between two non-reporter countries?

[17] We set by assumption $RD_{iFRA} = 1$, because of the multiplicative form of transport costs function.

[18] Benin, Niger, Senegal and Togo.

One approach is to use to ignore the missingobservations. Since we have a sample of 596 observations, this yields consistent estimators.

But here, the ignored observations are useful since they concern South-South trade flow which is the core of this paper. Another approach is then to use the intra WAEMU trade data to fill in the missing trade, but this yields an heterogeneity problem since the observations of these two database are seemingly different. However, we can combine the two data sources in the following way: for the extra-regional trade flows, we use COMTRADE data and for the intra-regional trade, we use WAEMU data. We have thus a complete data set usable for estimations.

We can also use an econometric device to bypass the problem. Since the missing observations are simply unavailable at random[19], then the complete obervations in the sample constitute a usable data set and the only issue is what possible helpful information could be salvaged from the incomplete observations. Many papers[20] have been written on this topic. Greene (1997) discusses this issue, starting from a general econometric model:

$$y = X\beta + \epsilon. \tag{7}$$

In this model, data are partitionned into two subsets: n_A complete observations and n_B observations for which y is missing. Let $\hat{y}_B$ be a predictor of y_B from X_B. The least squares slope vector is:

$$b_f = \left\{ \binom{X_A}{X_B}' \binom{X_A}{X_B} \right\}^{-1} \binom{X_A}{X_B}' \binom{y_A}{\hat{y}_B}$$

We can write this vector as:

$$b_f = \{X_A' X_A + X_B' X_B\}^{-1} \{X_A' y_A + X_B' \hat{y}_B\}. \tag{8}$$

Let b_A be the least squares slope in a regression that uses only the observations in group A, and define b_B likewise using $\hat{y}_B$. Then, we may write:

$$\begin{aligned} b_f &= \{X_A' X_A + X_B' X_B\}^{-1} \{X_A' X_A b_A + X_B' X_B b_B\} \\ &= F b_A + (1 - F)\, b_B \end{aligned}$$

[19] Non-reporting countries of WAEMU are Burkina Faso, Cote d'Ivoire and Mali, and there no reason to think that this stands for a predetermined reason.

[20] Afifi and Elashoff (1996, 1967), Haitovsky (1968), Anderson (1957), and Kelejian (1969) are a few of the major works.

where $F = \{X_A' X_A + X_B' X_B\}^{-1} X_A' X_A$. This equation gives a matrix weighted average of the two least squares estimators, and we have:

$$E(b_f) = F\beta + (1 - F)\, E(b_B). \tag{9}$$

It appears that b_f will be unbiased only if b_B is unbiased as well. What is the best estimate of $\hat{y}_B$?

Kelejian (1969) assessed the efficiency of the so-called "first-order method" which uses $\hat{y}_B = X_B b_A$, that is to use the regressors obtained with the complet sample n_A to estimate $\hat{y}_B$. This method passes the test of unbiasedness and appear to bring a gain of efficiency, even if we must account for the additional variation present in the predicted values.

In the following empirical estimations, we use three sets of data:

i) only COMTRADE data (specifications 1 and 4 inTables 6 and 10),

ii) COMTRADE data for extra-regional trade and WAEMU data for intra-regional trade (specifications 2 and 5 in Tables 6 and 10),

iii) COMTRADE data and replace the missing observations using the first-order method described above (specifications 3 and 6 in Tables 6 and 10).

4.2 Censored regressions

In the empirical part of the paper, we try to estimate the determinants of product specific trade flows. A common feature of statistics at such a level is that low observations are set equal to zero. In the PC-TAS database (using COMTRADE statistics), the trade value must be at least 50$. This is a typical censored observations problem and it is easy to prove that OLS are no longer relevant.

Indeed, let us consider the following model to be estimated:

$$y^* = x\beta + \varepsilon \tag{10}$$

for which we do not observe (y^*, x) but rather (y, x) where:

$$y = \max(0\ ,\ y^*). \tag{11}$$

It is the case that:

$$E(y \mid x) = E(y \mid x, y = 0) \cdot P(y = 0 \mid x) + E(y \mid x, y > 0) \cdot P(y > 0 \mid x)$$
$$\Rightarrow E(y \mid x) = \{x\beta + E(\varepsilon \mid \varepsilon > -x\beta)\} \cdot P(\varepsilon > -x\beta).$$

Since $E[y \mid x]$ is not a linear function of x, we cannot estimate β by OLS. One convenient way to solve such model is to use maximum likelihood estimation. In STATA, the estimations is straightforward using the TOBIT estimation device.

4.3 Instrumental variables estimation

The percentage of paved bilateral road is designed to measure the journey quality between two trading partners. This variable is endogenous in the sense that trading partners with high GDP are likely to have more paved road and thus a higher percentage of paved bilateral road. To correct for this endogeneity problem, we can use instrumental variables devices. Empirically, it appears to be relevant to adjust the percentage of paved bilateral road in the following way:

$$\ln \%PR_{ij} = \alpha_1 \ln AREA_i + \alpha_2 \ln AREA_j + \alpha_3 \ln INFRA_{ij} + \nu_{ij} \tag{12}$$

where $INFRA$ is the total length of paved bilateral road within and between countries i and j, reflecting the GDP level of the two trading partners, $AREA_i$ and $AREA_j$ being the surface area of countries i and j. We can then estimate the following triangular system:

$$\begin{aligned}\ln\left(\frac{E_{ij}}{E_{iFRA}}\right) = (1-\sigma)\,\alpha_1 \ln\left(\frac{SD_{ij}}{SD_{iFRA}}\right) + (1-\sigma)\,\alpha_2 \ln \frac{RD_{ij}}{RD_{iFRA}} \\ + (1-\sigma)\,\beta_1 FRENCH + (1-\sigma)\,\beta_2 WAEMU \\ + (1-\sigma)\,\gamma_1 \ln \%PR_{ij} + (1-\sigma)\,\gamma_2 \ln TRANSIT_{ij} \\ + (1-\sigma)\,\gamma_3 NBORDER_{ij} + (1-\sigma)\,\eta \ln\left(\frac{\Pi_j}{\Pi_{FRA}}\right) + \xi_{ij}.\end{aligned}$$

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

This is a triangular system equations which can be easily estimated by two-stage least squares[21]. In the following empirical estimations, we perform both OLS and two-stage least squares for the sake of comparison.

5 Estimating the geographical impediments impacts

This section aims at quantifying the impact of geographical an infrastructural disadvantages on the intra and extra regional trade of the Union. Let us first revisit the answers of the traditional gravity model, before implementing estimations from the Armington-based model we derived in section 3. These two sets of estimations will give an overview of the impact of geography on southern trade flows.

[21] Note that since ν_{ij} and ξ_{ij} are assumed independent and equation (12) does not depend on the relative import flows, the derivation is straightforward.

5.1 The traditional gravity model estimations

Table 6 shows the results for different specifications of the traditional gravity model. The dependent variable of these estimations is the import[22] of country i from country j ($\ln M_{ij}$). The regressors are the sea distance between country i and j ($\ln SD_{ij}$, which is 0 if country j is in the WAEMU), the road distance between country 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 wether country j is a french speaking country[23] ($FRENCH$), 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 percentage of the inter-state road between i and j that is paved ($\ln \%PR_{ij}$, for Paved Road between i and j), the transit distance between i and j ($\ln TRANSIT_{ij}$[24]) and the number of borders to cross from i to j ($NBORDER_{ij}$).

The specifications are organized in two ways:

i) according to the database used: specification 1 and 4 use only COMTRADE data , specifications 2 and 5 use COMTRADE data for extra-regional trade and WAEMU data for intra-regional trade, specifications 3 and 6 use the database completed by the first-order method,

ii) according to estimation method: specifications 1, 2 and 3 use OLS and specifications 4,5 and 6 use two stages least squares to correct for the endogeneity problem of the variable $\%PR_{ij}$.

The estimations are globally significant, with an R^2 statistic greater than 40%. The first three specifications are hardly different. The traditional gravity model variables are significant except for the GDP per capita of the exporter. A doubling of sea distance induces a 80%[25] reduction of a coastal importer. For a landlocked WAEMU country, we have to take into a account the inland distance, and thus a doubling of the total distance from an OECD country induces a 90% reduction of import. The doubling of the GDP of the importer multiplies import flows by 1.79 while a same variation of the exporter GDP multiplies it by 2.62. The GDP per capita of the importer has a surprising negative coefficient, which indicates that the richer a WAEMU country is (in term of GDP per capita), the less it imports. This fact is plausible if the country in concern is rich enough to produce all the goods needed by consumers. The dummy variables are also significant with the expected sign: a common language has a positive impact on trade flows and the intra-regional trade of

[22] Evaluated in current US $ value.

[23] We consider Switzerland, belgium and Canada as French speaking countries.

[24] Note that this variable is set equal to 0 if countries i and j are contiguous.

[25] If we focus only on the sea distance variable, we have $LnM_{ij} = -2.53 \ln SD_{ij}$ which yields $M_{ij} = Dist_{ij}^{-2.53}$, so that a doubling of the distance implies: $M_{ij}^{*} = 2^{-2.53} Dist_{ij}^{-2.53} = 0.17 M_{ij}$.

the WAEMU countries is very low with regard to the extra-regional trade flows. Being a french speaking exporter induces four times more import demand from WAEMU countries. Since the Armington based model is supposed to "filter" the "colonization effect" of France, we will assess wether this result vanishes or not.

There is a slight difference in these three specification when we focus on geographical variables: the data set using the first-order method to fill in missing observations yields a higher impact of the percentage of paved bilateral road. It appears that a 10% increase of this percentage induces a 11%[26] increase in trade. The other geographical variables are not statistically significant.

The three following specifications (4, 5 and 6) instrument[27] the percentage of paved bilateral road with the surface of country i (and j if it is a WAEMU country) and the total paved road in and between countries i and j. These estimations provide two interesting results:

i) the impact of the percentage of paved bilateral road is higher,

ii) the transit distance yields an additional impediment to trade.

Specifications 6 in Table 6 indicates that a 10% increase of paved bilateral road induces a 15% increase in trade flows and specification 5 suggests that transit distance accounts for 6% of trade cost[28].

These estimations of the traditional gravity model indicate a statistically significant effects of the traditional gravity model variable with the expected sign, except for the GDP per capita variable. Besides, being a french speaking country induces four times more import demand and the percentage of paved bilateral road proves to induce an increasing return to bilateral trade flows. It also appears that transit distance yields additioanl trade cost.

5.2 Does the imported product matter?

The COMTRADE data provide 2-digits trade flows statistics and we can use these desaggregated bilateral imports as the dependent variables. There are 99 2-digits products and for most of them, the WAEMU countries' imports flows are very low, and thus, cannot yield robust estimations.To bypass this problem, we regroup these products in 14 industries following Fontagné, Freudenberg & Péridy (1997), as resumed in Table 7.

For these product-specific estimations, it is not realistic to use GDP as a price proxy. For this reason, we perform a traditional gravity model instead

[26] If we focus only on the percentage of paved bilateral road, we have $LnM_{ij} = 1.06 \ln \%PR_{ij}$ which yields $M_{ij} = (\%PR_{ij})^{1.06}$, so that a 10% increase of this variable implies: $M^*_{ij} = 1.1^{1.06} (\%PR_{ij})^{1.06} = 1.11 M_{ij}$.

[27] When we regress the instrumented variables on all the intruments, the F-statistics is bigger than 10, which indicates that we have not a "weak instruments" problem, as has been shown by Staiger & Stock (1997).

[28] In this specification, trade costs are due to sea distance (73%), road distance (21%) and transit distance (6%).

of estimating the Armington-based model which requires a relative price proxy as shown in section 3. Besides, we do not fill in the missing observations for the non-reporting countries because it would be too tricky to guess the specific products they are supposed to exchange with each other. Thus we only perform a gravity model on the complete observations set (Table 8 and 9). We use a Tobit[29] estimation to take into account the low trade values that are censured to zero in most of trade statistics database. The estimations are globally significant except for Other Transport Equipment industry (KB) for which the p-value is 55%, implying that the estimated coefficients are all not statistically significant. We only focus on the 13 remaining industries in the following.

The sea distance has a very big negative impact on imports flows for three industries: Agriculture, hunting and forestry (AA), Food, beverages and Tobacco (AB) and Mining, quarrying and petroleum (B). This effect is less for five industries: Chemicals (CD), Basic metals and fabricated metals products (HI), Non-electrical machinery (JA), Professional goods (LA) and Other industries (N). This variable seems to be irrelevant for the remaining four industries: Wood, paper and printing (E), Leather and textile (FD), Non-metallic mineral product (G) and Electrical machinery (JB). It is interesting to interact this result with the WAEMU dummy effects specifying the intra-regional trade of these subsaharan African countries. Indeed, it clearly appears that the large sea distance effects industries are not a South-South trade outcome, while the Leather and Textile industry seems to be essentially a South-South trade issue, with a positive and significant coefficient for the WAEMU dummy variable.

The road distance is significant only for the Wood, paper and printing (E), the Non-metalic mineral products (G) and the Motor vehicles (KA) industries, with a surprising positive effect. Since the WAEMU dummy variable is statistically not relevant for these industries, this seems to suggest that the WAEMU landlocked countries, which are the most remote importers of our sample, have a greater import demand for these products.

The sharing of French language has a positive and significant effect on industries B, G, HI, JA, JB and KA. Analyzing the products in these industries, it seems that the colonial ties are still materring for two types of products: non agricultural raw materials and machineries.

In these estimations, the percentage of paved bilateral road is significant only in industries B, E and KA with a surprising negative sign. The transit distance is significant only in industries FD and HI with a surprising positive effect. As claimed previously, these results suggest that the most remote importers have a higher demand for thes products. Nevertheless, the number of borders crossed by the shipped goods has a negative and significant effect in industries E, FD and JA. It is interesting to notice that industry FD (leather and textile) is the most concerned with intra-WAEMU trade. Thus, a negative and significant "border effect" indicates that borders are still considerable impediments to the intra-WAEMU trade.

The industry-specific estimations provide interesting results on the place of

[29] See section 4.2 for theoretical justificqtion.

geography in intra and extra WAEMU trade. The sea distance reduction effect is unsurprisingly high for heavy products (Agriculture, forestry, mining...), while the positive road distance effect seems to be specific to WAEMU landlocked countries imports. The colonial ties seem to matter for non-agricultural raw materials and machineries. The bilateral geographical variables do not yield interesting results except for the number of borders crossed by the shipped Leather-Textile goods within the WAEMU. This industry is the most specific for the intra-WAEMU trade and exhibits a negative "border effect".

5.3 The Armington-based model estimations

Let us turn back to the final form of the theoretical model derived in section 3. The dependent variable is the relative import as described in section 3 and the regressors are those included in this final formulation:

$$\begin{aligned}\ln\left(\frac{E_{ij}}{E_{iFRA}}\right) &= (1-\sigma)\,\alpha_1 \ln\left(\frac{SD_{ij}}{SD_{iFRA}}\right) + (1-\sigma)\,\alpha_2 \ln\frac{RD_{ij}}{RD_{iFRA}} \\ &+ (1-\sigma)\,\beta_1 FRENCH + (1-\sigma)\,\beta_2 WAEMU \\ &+ (1-\sigma)\,\gamma_1 \ln \%PR_{ij} + (1-\sigma)\,\gamma_2 \ln TRANSIT_{ij} \\ &+ (1-\sigma)\,\gamma_3 NBORDER_{ij} + (1-\sigma)\,\eta \ln\left(\frac{\Pi_j}{\Pi_{FRA}}\right) + \xi_{ij}.\end{aligned}$$

As in the gravity model estimations, the specifications are organized in two ways:

i) 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 data for intra-regional trade, specifications 3 and 6 use the database completed by the first-order method,

ii) according to estimation method: specifications 1, 2 and 3 use OLS and specifications 4,5 and 6 use two stages least squares to correct for the endogeneity problem of the variable $\%PR_{ij}$.

The results are reported in Table 10. The estimations are globally significant with an R^2 statistic around 20%. Let us focus on specifications 4, 5 and 6. The relative sea distance variable has a negative and significant effect on the relative import, but different from that of the sea distance variable in the traditional gravity model estimation. The relative price factor has a negative and significant effect on relative import flows, indicating that an increase of an exporter price relatively to France is correlated with a decrease of the import from this country relatively to imports from France, which indicates a substitution effect. In the three specifications, a 10% increase of paved bilateral road induces more than 10% increase in trade flows. It also appears that excluding french imports, the WAEMU countries trade more than three times with french speaking countries.

An interesting result here is the substitution effect captured by the relative GDP deflator. WAEMU countries seem to substitute "cheap" trading partners to “expensive” ones. Indeed, specification 6 indicates that if a price in a exporter double relatively to French price, the importer reduces its imports from this country by 70%. Prices thus prove to be relevant in the choice of trading partners.

The second interesting result is the increasing return to scale of paved bilateral road on trade flows. We used the elasticity of this variable (cf. specification 6 in Table 10) to compute the extra import flows created if the percentage of paved bilateral road was completed to 100% for the inter-state roads which are not totally paved. The results presented in Table 11 indicate that the lower the percentage of paved bilateral road is, the higher is the impact of this infrastructure improvement on the import flows. The trading partner most concerned are Mali and Senegal. For the year 1998, the estimations suggest that improving the inter-state paved road to 100% would have created more than four times trade between these countries. This seems to be a big issue for the Union because Senegal is the second most dynamic economy after Côte d'Ivoire, and its being remote from the other member tends to weaken the Union. Besides, this remoteness also affects the trade flows between Senegal and Côte d'ivoire, the estimations suggesting a 100% pavement of the road between these two countries would double trade flows between them.

If we take into account all the extra trade created by this “100% pavement of inter-state roads”, the trade flows in this region is three times more important, which is not negligeable if we recall the 3% intra-regional trade during the 90s. The two sets of estimations (traditional gravity and the Armington-based models) seem to confirm the exacerbating geographical impediments faced by southern country.

6 Conclusion

In this paper, we aimed at analyzing the impact of geography on South-South trade starting by the puzzle that indicates a global disadvantage faced by landlocked countries, and particularly those in the South. We focused on the countries of the West African Economic and Monetary Union, which have suitable data for such an analysis.

The traditional gravity model estimate indicate a statistically significant effect of the traditional gravity model variable with the expected sign, except for the GDP per capita variable. Being a French speaking country induces four times more import demand and the percentage of paved bilateral road has an increasing return to scale on trade flows. We also found out that transit distance proves to yields additional trade costs, accounting for 6% of the trade costs considered in the model.

The industry-specific estimations provide interesting additional results, the most appealing being the fact that colonial ties seem to matter for non-agricultural raw materials and machineries and that leather-textile industry is the most specific industry for the intra-WAEMU trade, exhibiting a negative “border effect”.

The estimations from the Armington-based model we developed provide three interesting results. First, the increasing return to scale of paved bilateral road on trade flows is confirmed and reinforced. Second, if all the inter-state roads were paved, the countries will trade three times more than what is observed, hence existing untapped trade potential. Finally it seems that WAEMU countries substitute "cheap" trading partners to "expensive" ones.

The main aim of this paper was to estimate to what extent geographical disadvantages are a handicap in South-South trade. We focused on the West African Economic and Monetary Union but the results might be extented to other southern regions. Indeed, two types of disadvantage seem to affect these countries: one due to the location in a southern area and one due to higher impediments when crossing transit spaces within this area. Beyond this result, this paper proposes an alternative way to analyze the determinants of trade flows in southern areas using an armington-based model and particular definitions of geographical impediments. Further studies on other geographical areas, different databases and proxies of these geographical impediments could re-explore this approach.

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ANNEXES

Table 1: The disadvantage of landlocked countries
(unit: billion $ US, current value 2000)

		Developing countries				Developed countries
		Africa	Asia	America	Mideast	
Landlocked	Export	0.7	0.5	1.5		69.6
	GDP	3.1	2.1	7.9		149.2
	$\frac{Export}{GDP}$	0.2	0.3	0.2		0.5
Non-Landlocked	Export	4.6	61.4	13.8	22.0	232.8
	GDP	13.22	141.5	66.6	54.7	1178.5
	$\frac{Export}{GDP}$	0.4	0.4	0.2	0.4	0.2

Sources: World Development Indicators 2000 and our calculations.

Table 2: The disadvantage of landlocked countries: a gravity model approach
Dependent variable: $Ln\,(Export92_{ij})$
Tobit estimations

	1	2	3	4	5
LnDIST_{ij}	-1.41***	-1.44***	-1.64***	-1.64***	-1.66***
	(-25.08)	(-25.79)	(-28.81)	(-28.80)	(-29.34)
LnGDP_i	1.43***	1.41***	1.39***	1.39***	1.40***
	(60.36)	(59.79)	(59.39)	(59.39)	(59.56)
LnGDP_j	1.04***	1.03***	1.01***	1.01***	1.02***
	(44.74)	(44.34)	(44.02)	(44.02)	(44.09)
LnGDPPC_i	-0.00	-0.07***	-0.12***	-0.12***	-0.10***
	(-0.14)	(-2.33)	(-3.87)	(-3.87)	(-3.42)
LnGDPPC_j	0.08***	0.01	-0.04	-0.04	-0.02
	(2.67)	(0.23)	(-1.23)	(-1.23)	(-0.72)
CONTIG_{ij}	-0.24	-0.57**	-0.45	-0.45	-0.49*
	(-0.88)	(-2.09)	(-1.63)	(-1.63)	(-1.79)
LANG_{ij}	0.41***	0.35***	0.47***	0.47***	0.46***
	(3.78)	(3.26)	(4.39)	(4.39)	(4.25)
1LLE	0.50***	0.43***	0.30**	0.30***	
	(3.39)	(2.91)	(2.04)	(2.04)	
1LLNE	-0.52***	-0.36***	-0.29***	-0.30***	
	(-4.75)	(-3.29)	(-2.65)	(-2.74)	
2LLNE	-1.59***		-0.45		
	(-2.65)		(-0.75)		
1AFR		-1.14***	-0.88***	-0.88***	-0.91***
		(-13.33)	(-10.17)	(-10.16)	(-10.63)
2AFR			-2.62***	-2.64***	-2.68***
			(-14.93)	(-15.14)	(-15.38)
CONST	-8.13***	-5.92***	-3.05***	-3.06***	-3.18***
	(-14.33)	(-10.07)	(-4.98)	(-4.98)	(-5.25)
Pseudo-R^2	0.10	0.11	0.11	0.11	0.11
P-value	0.00	0.00	0.00	0.00	0.00
N	14,383	14,383	14,383	14,383	14,383

***represents a 99% level of significance

** represents a 95% level of significance

* represents a 90% level of significance

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

Table 3: Roads distribution throughout the Union

Country	Roads	% paved	Density per 100 km^2
BEN	13842	9	10.8
BFA	13117	14	6.7
CIV	68351	8	17.0
MLI	14776	17	2.0
NER	13800	25	2.7
SEN	14358	29	21.1
TGO	8108	20	28.4
Union	146352	14	5.9

Sources: Commission of the West African Economic and Monetary Union.

Table 4: Border equipments and accessibility to some trading partners

Border	Economic Centers	Distance (km)	Road distance	% paved	Borders scores
CIV-BFA	Abidjan-Ouagadougou	832	1176	100	35
CIV-MLI	Abidjan-Bamako	925	1184	100	50
BEN-TGO	Cotonou-Lomé	160	189	100	30
TGO-BFA	Lomé-Ouagadougou	757	970	100	40
MLI-SEN	Bamako-Dakar	1044	1486	31	20
BFA-NER	Ouagadougou-Niamey	415	537	100	40
BFA-MLI	Ouagadougou-Bamako	705	610	100	40
NER-BEN	Niamey-Cotonou	785	1041	100	30

Sources: Commission of the West African Economic and Monetary Union and our calculations.

Table 5: Bilateral share of GDP and GDP per capita in the WAEMU

Landlocked	Contiguous	Bilateral Share of GDP	Bilateral Share of GDP par capita
No	No	0.53	0.54
No	Yes	0.56	0.59
Yes	No	0.40	0.37
Yes	Yes	0.46	0.44

Sources: World development indicators and our calculations.

Table 6: The traditional gravity model estimation, least squares with robust variance estimators

Dependant variable: LnMij

	1	2	3	4	5	6
$LnSD_{ij}$	-2.53***	-2.53***	-2.53***	-2.54***	-2.03***	-2.54***
	(-10.70)	(-10.68)	(-10.68)	(-10.74)	(-8.09)	(-10.73)
$LnRD_{ij}$	-0.65**	-0.65***	-0.75***	-0.96***	-0.59***	-0.97***
	(-2.56)	(-3.65)	(-4.14)	(-3.32)	(-2.86)	(-4.93)
FRENCH	1.40***	1.40***	1.40***	1.39***	-0.37	1.39***
	(9.10)	(9.12)	(9.13)	(9.10)	(-1.09)	(9.11)
WAEMU	-16.80***	-16.81***	-16.88***	-17.20***	-11.23***	-17.21***
	(-7.48)	(-7.71)	(-7.74)	(-7.63)	(-4.78)	(-7.88)
$LnGDP_i$	0.84***	0.84***	0.85***	0.86***	0.83***	0.86***
	(6.01)	(6.38)	(6.39)	(6.05)	(5.25)	(6.44)
$LnGDP_j$	1.39***	1.39***	1.39***	1.40***	1.08***	1.40***
	(22.07)	(22.39)	(22.24)	(22.29)	(14.31)	(22.59)
$LnGDPPC_i$	-0.90**	-0.90***	-0.91***	-0.88**	-0.35	-0.88**
	(-2.28)	(-2.59)	(-2.59)	(-2.21)	(-0.84)	(-2.51)
$LnGDPPC_j$	0.02	0.02	0.03	0.02	0.31***	0.01
	(0.23)	(0.22)	(0.31)	(0.19)	(4.01)	(0.19)
$Ln\%PR_{ij}$	0.88**	0.88***	1.06***	1.43***	0.99***	1.44***
	(2.16)	(3.02)	(3.58)	(2.96)	(2.88)	(4.34)
$LnTRANSIT_{ij}$	-0.09	-0.09	-0.10	-0.11	-0.16*	-0.11
	(-0.85)	(-1.04)	(-1.11)	(-0.94)	(-1.67)	(-1.17)
$NBORDER_{ij}$	0.21	0.21	0.27	0.35	-0.08	0.36
	(0.66)	(0.91)	(1.16)	(1.07)	(-0.26)	(1.48)
CONST	11.95***	11.97***	11.89***	11.66***	4.74	11.65***
	(3.74)	(4.08)	(4.04)	(3.64)	(1.45)	(3.97)
R^2	0.57	0.58	0.58	0.57	0.41	0.58
P-value	0.00	0.00	0.00	0.00	0.00	0.00
N	596	640	640	596	640	640

***represents a 99% level of significance

** represents a 95% level of significance

* represents a 90% level of significance

Notes: Sepicifications 4, 5 and 6 are estimated with IV methods, the intrumented variable being $Ln\%PR_{ij}$, the instruments being the log of the surface of country i and j, and the total paved road in and between countries i and j. Specifications 1 and 4 use only the COMTRADE date, specifications 2 and 5 use COMTRADE data for the extra-regional trade flows and WAEMU data for the intra-regional flows, specifications 3 and 6 use COMTRADE data and replace the missing trade flows using the so-called "first-order" method.

Table 7: Aggregating the 2-digits products by industry

Industry	**2-digits products**	**label**
AA	01-14	Agriculture, Hunting, Forestry
AB	15-24	Food, Beverages, Tobacco
B	25-27	Mining, Quarrying, Petroleum
CD	28-40	Chemicals
E	44-49	Wood, Paper, Printing
FD	41-43, 50-67	Textile, Leather
G	68-72	Non-metallic mineral products
HI	73-83	Basic metals and Fabricated metals products
JA	84	Non-electrical machinery
JB	85	Electrical machinery
KA	87	Motor vehicles
KB	86, 88, 89	Other transport equipment
LA	90-92	Professional goods
N	93-99	Other industries

Table 8: TOBIT estimations of the bilateral imports by industry
Dependant variable: $\ln M_{ij}^{Ind}$

	AA	AB	B	CD	E	FD	G
LnSD_{ij}	-2.36	-4.60***	-3.75***	-1.27***	-0.14	-0.19	-0.65
	(-3.87)	(-8.04)	(-4.77)	(-3.43)	(-0.33)	(-0.53)	(-1.43)
LnRD_{ij}	0.03	0.36	0.54	0.05	0.93***	-0.36	0.74*
	(0.06)	(0.77)	(0.87)	(0.13)	(2.61)	(-1.03)	(1.64)
FRENCH	0.14	-0.56	1.58**	0.20	0.23	0.29	1.40***
	(0.21)	(-1.07)	(2.15)	(0.51)	(0.61)	(0.73)	(2.79)
WAEMU	-15.46***	-31.93***	-22.85***	-8.75	3.19	6.06*	-3.30
	(-2.67)	(-5.91)	(-3.21)	(-2.46)	(0.81)	(1.71)	(-0.76)
LnGDP_i	0.48***	0.32	0.93	1.86***	0.87*	-0.29	1.29**
	(0.63)	(0.50)	(1.10)	(3.86)	(1.83)	(-0.58)	(2.25)
LnGDP_j	1.07	0.76	-0.14	-0.25	-0.17	-1.10	0.09
	(0.85)	(0.73)	(-0.11)	(-0.33)	(-0.22)	(-1.44)	(0.09)
LnGDPPC_i	0.78***	0.98***	0.45**	0.84***	0.12	0.74***	0.29*
	(4.26)	(6.38)	(1.97)	(6.67)	(0.94)	(5.81)	(1.87)
LnGDPPC_j	0.50**	0.23	0.53**	0.45***	0.69***	0.22	0.58***
	(2.30)	(1.29)	(2.01)	(2.85)	(3.81)	(1.52)	(3.34)
$\text{Ln\%PR}_{ij}$	0.66	-0.71	-1.72*	-0.39	-1.74***	-0.38	-0.87
	(0.84)	(-0.91)	(-1.93)	(-0.69)	(-3.49)	(-0.68)	(-1229)
LnTRANSIT_{ij}	-0.39	0.04	0.27	-0.04	0.09	0.57***	-0.30
	(-1.56)	(0.17)	(0.97)	(-0.19)	(0.54)	(3.22)	(-1.12)
NBORDER_{ij}	-0.33	-0.97	-0.87	1.17**	-0.79*	-2.06***	-0.26
	(-0.43)	(-1.43)	(-1.10)	(2.22)	(-1.71)	(-3.83)	(-0.44)
CONST	-4.88	24.76***	16.81***	-5.83	-9.94	3.48	-2.03
	(-0.51)	(3.00)	(1.55)	(-0.96)	(-1.56)	(0.58)	(-0.27)
Pseudo-R^2	0.03	0.06	0.07	0.06	0.05	0.07	0.04
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	392	401	306	476	375	417	334

***represents a 99% level of significance
** represents a 95% level of significance
* represents a 90% level of significance

Table 9: TOBIT estimations of the bilateral imports by industry (continuing)
Dependant variable: $\ln M_{ij}^{Ind}$

	HI	JA	JB	KA	KB	LA	N
LnSD_{ij}	-1.48***	-0.79***	-0.24	-0.27	-0.26	-0.94***	-1.04***
	(-3.41)	(-2.88)	(-0.78)	(-0.79)	(-0.21)	(-2.93)	(-2.63)
LnRD_{ij}	-0.11	0.38	0.50	0.81*	4.98	-3.00	-0.24
	(-0.26)	(0.90)	(1.37)	(1.85)	(0.63)	(-0.30)	(-0.35)
FRENCH	1.18***	0.84***	0.98***	1.10***	0.43	0.03	-0.20
	(2.69)	(2.79)	(3.07)	(3.23)	(0.46)	(-0.11)	(-0.51)
WAEMU	-9.41**	-0.52	-0.90	0.03	-	-	-6.14
	(-2.21)	(-0.17)	(-0.29)	(0.01)	-	-	(-1.55)
LnGDP_i	1.63***	0.64*	0.62	0.90**	0.85	1.57***	0.42
	(3.07)	(1.65)	(1.49)	(2.01)	(0.64)	(3.39)	(0.78)
LnGDP_j	-1.76**	1.06*	0.27	-0.73	1.65	0.04	-0.15
	(-1.99)	(1.65)	(0.40)	(-0.99)	(0.64)	(0.05)	(-0.17)
LnGDPPC_i	0.49***	0.82***	0.57***	0.73***	0.25	0.44***	0.82***
	(3.45)	(8.80)	(5.21)	(6.25)	(0.88)	(4.18)	(6.12)
LnGDPPC_j	0.22	0.58***	0.35**	0.58***	0.45	0.34**	0.65***
	(1.40)	(4.63)	(2.44)	(4.02)	(0.86)	(2.17)	(3.36)
$\text{Ln\%PR}_{ij}$	-0.48	-1.13	-0.73	-1.16*	3.13	-4.22	1.08
	(-0.78)	(-1.60)	(-1.34)	(-1.79)	(0.34)	(-0.54)	(0.97)
LnTRANSIT_{ij}	0.38*	0.25	-0.15	-0.28	-6.70	5.36	-0.39
	(1.86)	(1.04)	(-0.85)	(-1.20)	(-0.51)	(0.38)	(-1.30)
NBORDER_{ij}	-0.36	-1.89***	0.43	-0.19	-4.10	-2.14	0.08
	(-0.65)	(-2.94)	(0.92)	(-0.24)	(-0.57)	(-0.35)	(0.13)
CONST	11.61*	-17.68***	-12.74**	11.72***	-14.42	-3.33	-6.60
	(1.69)	(-3.67)	(-2.43)	(-6.92)	(-0.67)	(-0.56)	(-0.91)
Peseudo-R^2	0.06	0.12	0.05	0.07	0.01	0.06	0.07
P-value	0.00	0.00	0.00	0.00	0.55	0.00	0.00
N	378	462	433	408	188	318	371

***represents a 99% level of significance
** represents a 95% level of significance
* represents a 90% level of significance

Table 10: The Armington-based model estimations, OLS with robust variance estimators

Dependant variable: $\mathrm{Ln}\frac{E_{ij}}{E_{iFRA}}$

	1	2	3	4	5	6
$\mathrm{Ln}\frac{SD_{ij}}{SD_{iFR}}$	-1.53***	-1.53***	-1.53***	-1.53***	-1.51***	-1.53***
	(-5.08)	(-5.08)	(-5.09)	(-5.06)	(-4.99)	(-5.07)
$\mathrm{Ln}\frac{\Pi_j}{\Pi_{FR}}$	-1.71***	-1.71***	-1.72***	-1.74***	-1.60***	-1.75***
	(-6.72)	(-6.79)	(-6.81)	(-6.78)	(-6.55)	(-6.85)
$\mathrm{Ln}\frac{RD_{ij}}{RD_{iFRA}}$	-0.62*	-0.62***	-0.77***	-1.06***	-0.69***	-1.08***
	(-1.80)	(-2.57)	(-3.13)	(-2.72)	(-2.66)	(-4.09)
$\mathrm{Ln}\%\mathrm{PR}_{ij}$	0.94*	0.93**	1.20***	1.71***	1.23***	1.74***
	(1.77)	(2.54)	(3.21)	(2.70)	(2.84)	(4.07)
$\mathrm{LnTRANSIT}_{ij}$	-0.02	-0.02	-0.03	-0.03	-0.12	-0.03
	(-0.14)	(-0.15)	(-0.23)	(-0.23)	(-0.98)	(-0.28)
$\mathrm{NBORDER}_{ij}$	0.11	0.11	0.20	0.30	0.00	0.31
	(0.28)	(0.37)	(0.68)	(0.74)	(0.01)	(1.03)
FRENCH	1.28***	1.28***	1.27***	1.27***	1.31***	1.27***
	(6.57)	(6.58)	(6.57)	(6.54)	(6.74)	(6.55)
WAEMU	-13.87***	-13.86***	-14.04***	-14.28***	-14.11***	-14.30***
	(-4.67)	(-4.85)	(-4.91)	(-4.79)	(-4.82)	(-4.99)
CONST	-3.92***	-3.91***	-3.91***	-3.92***	-3.96***	-3.92***
	(-27.13)	(-27.17)	(-27.14)	(-27.14)	(-27.42)	(-27.17)
R^2	0.17	0.18	0.18	0.17	0.16	0.18
P-value	0.00	0.00	0.00	0.00	0.00	0.00
N	620	664	664	620	664	664

***represents a 1% level of significance

** represents a 5% level of significance

* represents a 10% level of significance

Notes: Sepicifications 4, 5 and 6 are estimated with IV methods, the intrumented variable being $\mathrm{Ln}\%\mathrm{PR}_{ij}$, the instruments being the log of the surface of country i and j, and the total paved road in and between countries i and j. Specifications 1 and 4 use only the COMTRADE date, specifications 2 and 5 use COMTRADE data for the extra-regional trade flows and WAEMU data for the intra-regional flows, specifications 3 and 6 use COMTRADE data and replace the missing trade flows using the so-called "first-order" method.

Table 11: Extra 1998 import flows when the % of paved bilateral roads is raised to 100[30] (units: 1,000$)

Country i	Country j	$\%PR_{ij}$	ΔM_{ij}	M_{ij}	$\frac{\Delta M_{ij}}{M_{ij}}(\%)$
BEN	BFA	55	1,332	936	142
BEN	SEN	69	6,836	8,745	78
BFA	BEN	55	248	174	142
BFA	SEN	57	4,414	3,362	131
CIV	SEN	62	15,162	14,217	107
MLI	NER	80	232	533	44
MLI	SEN	31	115,221	29,751	387
NER	MLI	80	470	1,081	44
NER	SEN	65	804	858	94
SEN	BEN	69	112	144	78
SEN	BFA	57	77	59	131
SEN	CIV	62	26,189	24,558	107
SEN	MLI	31	11,723	3,027	387
SEN	NER	65	11	11	100
SEN	TGO	68	98	119	82
TGO	SEN	68	2,744	3,352	82
Total			185,672	90,925	204

Sources: WAEMU Comission and our calculations.

[30] In fact, we have $\Delta M_{ij} = 1.74 \times \frac{\Delta\%PR_{ij}}{\%PR_{ij}} \times M_{ij}$, using the estimated coefficient of $\%PR_{ij}$ in specification 4 of Table 10.