Are African exports that weak ? A trade in value-added approach

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Abstract: African countries are known to export less than any other group of countries in the world. Numerous studies have pointed out the high level of transport costs related to the lousy quality of transport infrastructures in the African continent to be the main explanation of this situation. We first show that depending on the estimator used, African countries on aggregate do not trade necessary less than the average country in the world when it comes to gross exports, even if they underperform clearly as regards final goods exports. We also formulate a model for trade in value-added by adapting the Anderson and Van Wincoop's gravity equation to take into account the structure of value-added exports. The proposed model highlights the importance of indirect trade costs, which are trade costs of third countries through which the exported value-added of the origin country passes to reach its final destination. When we control for these indirect trade costs, it appears that the penalty on the direct trade costs between African countries' and their partners is at least two times lower for value-added exports than what is predicted for gross exports and even six times lower in comparison to final goods exports.

Keywords: Global value chains, Gravity model, trade costs, African trade

JEL classification code : F100

1 Introduction

The weakness of African exports is an old but still current issue. As a matter of fact, since the independencies, the share of this continent in world exports has never been above 8% and has declined quasi continuously despite few episodes of growth. As of today, the African share of world exports only represents 2% according to WTO data. This low share is a real problem for several reasons. Firstly, it has been shown that in many countries including African, exporting firms pay higher wages and are larger than non-exporting firms in terms of the number of employees (Bernard et al., 2007; Rankin et al., 2006). An increase in exports is therefore potentially welfare-improving in this regard for a continent where extreme poverty is still a pervasive issue.

Secondly, as African countries are generally small in term of economic size, an increase in exports could, therefore, compensate for their weak domestic demand. This explains the numerous trade agreements implemented by African countries with their regional and international partners since the beginning of the 1990s to gain access to larger markets. These trade agreements do not seem to have increased African countries exports whatsoever, or at least their share in world exports according to the previous stylized facts. However, are these countries exports as weak as it appears? More formally, is there a benchmark level that African countries exports fall short to meet?

This question has been widely discussed in the literature, and there is a consensus among researchers that these countries trade less in comparison to others with similar characteristics, despite few studies with more nuanced results.[1] Limao and Venables (2001), for example, confirm this idea. They show that there is a penalty on intra-sub-Saharan African (SSA) trade flows and that this penalty is overturned once the level of their transport infrastructure is accounted for. According to them, transport infrastructures, therefore, play a key role in explaining the transport costs penalty borne by intra-SSA trade.

Freund and Rocha (2011) reached a similar conclusion regarding the weakness of African exports compared to the benchmark. They, however, pointed out a different trade impediment even if related to transport infrastructures, notably the transit time from the factory to the port of expedition. They found that cutting the transit time in half, that is to say (3.5 days on average) would increase African trade by 30 per cent. The negative role of transport infrastructures on African trade is also highlighted in Buys et al. (2006).

[1] Foroutan and Pritchett (1993) find that African countries do not trade less than countries with similar economic characteristics. Rodrik (1998) explains the weakness of African exports by the low-income growth in this continent in the period studied.

Although interesting, some concerns can be raised regarding the results of these studies, and this is related to the estimation methods of the theoretical model used. In fact, the proper estimation of the gravity model, the framework on which all these findings are founded has been widely discussed in the literature. It is, for example, acknowledged that the use of ordinary least squares to estimate this model as commonly done by the previous studies is not devoid of risks in the presence of heteroskedasticity, something highly likely in trade data (Silva and Tenreyro, 2006).

Besides, most of the studies on African states' trade performance use exporter and importer GDPs to control for the mass variables. When bilateral gross exports are the dependent variable and trade in intermediate goods is present, it is clear that the GDPs are not the proper mass variables. This is because bilateral gross exports embed previously imported intermediate inputs that are used to produce the exported final goods, while GDP is solely composed of domestic value-added. Using an improper mass variable could alter the scores of trade performance as countries that use more imported intermediate inputs to produce their exported goods would be found to export more than what their GDP allows.

Moreover, exporter fixed effects are in general, not included in the estimations. Though, to estimate the model rigorously, exporter and importer fixed effects should be included to adequately control for all the idiosyncratic variables as the multilateral resistance for example. But, as the problem is to assess the trade performance of different states, it is difficult to do so with the presence of fixed effects because they capture a share of what we are interested in. It is thus very interesting to determine whether the alleged weakness of African exports according to the benchmark continues to exist when the gravity model is estimated correctly and rigorously.

To tackle the concerns mentioned above, we have a threefold approach. We firstly use proper mass variables instead of GDP to estimate the model, secondly, we use the Poisson pseudo maximum likelihood estimator (PPML) instead of ordinary least squares to avoid the issues related to heteroskedasticity, and thirdly, on top of using gross exports as dependent variable, we calculate each state value-added exports and reformulate the gravity model in order to take into account the particularity of these trade flows before estimating it.

Doing this represents a real improvement in the estimation of the gravity equation. This is because it allows us to determine the real increase in international demand that a country could expect after reducing its trade costs with its trading partners. In fact, trade costs likely have a differential impact on value-added exports and gross exports. The composition of gross exports that include domestic and foreign contents is the main reason.

A trade cost could, therefore, impact the foreign content in gross exports more than the domestic content. This is for instance suggested by Johnson and Noguera (2012b), who showed that there had been a continuous decline of the value-added to gross exports ratio from 1970 to 2009, concomitantly with a steep decline of trade costs during this period.

Estimating the model with value-added exports thus allows us to assess the real impact of trade costs on this variable, and naturally eases the identification of the real contribution a change in trade cost could make to an economy's material well-being in terms of real income. Some authors as Guilhoto et al. (2015) or Johnson and Noguera (2012b) using classical gravity equations have already estimated models with bilateral value-added exports as the dependent variable. However, because of its more complex structure, these traditional models as that of Anderson and Van Wincoop (2003) or other variants as Eaton and Kortum (2002) or Chaney (2008) are not completely suitable to explain this type of trade flows. This is because in contrast to direct bilateral exports that these models explain, a given country value-added exports to a particular destination depend on third countries final goods exports to this destination (Koopman et al., 2014). A better modelling strategy should, therefore, take this into account.

In this sense, Aichele and Heiland (2018) derive a structural expression for value-added exports that they use to perform counterfactual analysis in general equilibrium, but they do not estimate a reduced form gravity equation. Noguera (2012), proposes an approach that combines the gross trade equation with a log-linear Taylor approximation of bilateral value-added exports around a benchmark equilibrium. This gives an equation that relates bilateral value-added exports in change to gravity variables. Although taking into account the trade costs of third countries with the destination of final consumption, his interesting method presents, however, the caveat to estimate a log-linear gravity equation. In the presence of heteroskedasticity in the data as have shown Silva and Tenreyro (2006), estimating this kind of log-linearized gravity models with ordinary least squares as it is done by Noguera (2012) could lead to biased parameter estimates.

We propose a framework that preserves the non-linearity of the model and thus, allows us to avoid this potential problem. Unlike Noguera (2012) who finds that the bilateral trade cost elasticity of value-added exports is about two-thirds of that of gross exports, we find that it is only the standard errors regarding the trade costs parameters that are lower for value-added exports in comparison to gross trade flows. Consequently, the heterogeneity across countries regarding the magnitude of the trade costs parameters is lower for value-added exports.

For instance, African countries face a sizable penalty on their trade costs coefficients in comparison to the benchmark when the dependent variable is gross exports. However, with value-added exports, this penalty is at least halved and even six times lower respectively in comparison to gross exports and final goods exports. It thus means that an improvement of transport infrastructures, for example, that can considerably reduce African transport costs, could significantly increase their gross exports but have a smaller impact on their value-added exports.

This result has many implications in terms of policies because policymakers are more concerned about the exported value-added for the considerations detailed above. We thus contribute to the literature by highlighting this differential impact of trade costs on African value-added exports and gross exports, but also by proposing a model to estimate the gravity equation for value-added exports flows appropriately. The remainder of the paper is organized as follows. Section 2 presents the structural gravity model of Anderson and Van Wincoop (2003) and discusses some considerations about its empirical estimation. Section 3 proposes a gravity model for value-added exports and sections 4 and 5 present respectively the data and the empirical results. Finally, section 6 contains some concluding remarks.

2 The structural Gravity Model and its estimation

Anderson and Van Wincoop's model has the following form:

$$X_{sj} = \frac{Y_s D_j}{Y} \left(\frac{t_{sj}}{\Pi_s P_j} \right)^{1-\sigma} \tag{1}$$

With $$P_j^{1-\sigma} = \sum_s \frac{Y_s \; t_{sj}^{1-\sigma}}{{\Pi_s}^{1-\sigma}} \tag{2}$$

$$\Pi_s^{1-\sigma} = \sum_j \frac{D_j \; t_{sj}^{1-\sigma}}{P_j^{1-\sigma}} \tag{3}$$

And $$Y_s = \sum_{j=1}^{N} X_{sj} \tag{4}$$

And where Y is the world GDP, $\mathrm{Y_s}$ and $\mathrm{D_j}$ respectively the GDP[2] and the expenditures of countries s and j and t_{sj} country j import costs for goods from country s. $1 - \sigma < 1$

[2]The GDP mentioned is the sum of the value-added created inside a country which also includes net taxes on intermediate inputs. See Timmer et al. (2015)

is the elasticity of trade with respect to trade costs and Π_s and P_J represent respectively the exporter and importer outward and inward multilateral resistance terms. Given its nonlinear nature, a log-linear version of this equation is often estimated. We have:

$$\ln X_{sj} = a_0 + a_1 \ln Y_s + a_2 \ln D_j + (1-\sigma) \ln t_{sj} - (1-\sigma) \ln \Pi_s - (1-\sigma) \ln P_J + \varepsilon_{sj} \quad (5)$$

Where a_0 is the constant, and ε_{sj} is the error term. We use the following equation for the trade cost factor:

$$T_{sj} = d_{sj}^{\delta_1}. \; exp(\delta_2 cont_{sj} + \delta_3 lang_{sj} + \delta_4 ccol_{sj} + \delta_5 col_{sj} + \delta_6 rta_{sj} + a_i border_{sj}) \quad (6)$$

With d_{sj} representing the bilateral distance, and $cont_{sj}$, $lang_{sj}$, $ccol_{sj}$, col_{sj}, $border_{sj}$ representing dummies respectively for the presence of a common border, a common official language, a common colonizer, if the territory is or has been one of its partner colonies in the past and for the country's trade with itself. Regarding exporter and importer multilateral trade resistances which are generally unobservable, the best way to control for them is by using exporter and importer fixed effects (Baldwin and Taglioni, 2006).

Estimating a log-linearized model is not exempted of flaws, particularly because it raises the issue of Jensen inequality [E(ln y)≠ln E(y)] which biases the estimates in the presence of heteroskedasticity. As Silva and Tenreyro (2006) pointed out, the expected value of the logarithm of a random variable is a function of its mean, but also of the higher-order moments of the distribution. So, for instance, if the error term variance in equation (5) is a function of the independent variables as it is generally the case in trade data[3], the exogeneity assumption $E(e_{sj}|x) = 0$ required for the consistency of OLS will be violated. They, therefore, advocate for using the Poisson Pseudo maximum likelihood estimator instead, an estimation method which avoids log-linearization and has several other interesting features that comply with some characteristics of trade data as the existence of zero trade flows. The estimated model thus becomes:

$$X_{sj} = \{exp(a_0 + a_1 \ln Y_s + a_2 \ln D_j + (1-\sigma) \ln T_{sj} - (1-\sigma) \ln \Pi_s - (1-\sigma) \ln P_J) + \varepsilon_{sj}\} \quad (7)$$

With X_{sj} representing exports in value from country s to country j, the other variables remaining unchanged. When we include importer and exporter fixed-effects to control for

[3] According to the authors the higher is the conditional Esperance of trade flows, the higher the variance of trade flows with respect to the regressors probably is

the multilateral resitance terms, we get the following empirical model :

$$X_{\text{sj}} = exp(u_s + \ln T_{sj}^{1-\sigma} + \ u_j) \tag{8}$$

where u_j and u_s are respectively estimates of the importer and exporter fixed effects, and Y_0 the income of the reference country.

Originally designed for gross trade flows, the Anderson and Van Wincoop (2003) gravity model is not necessarily suitable to analyse value-added trade flows as we will see in the next section.

3 A gravity model for value-added exports

Trade flows between countries are generally analysed using data on bilateral gross exports. As we know, these data are obtained by recording the gross value of goods as they cross borders. With a fragmented production process involving many countries, inputs cross borders many times before reaching their destination, and it is impossible to determine where the value-added embodied in the flows exactly come from and where it is ultimately consumed. This poses a problem when we want to explain trade flows using a standard gravity model because the value-added to gross exports ratio is highly heterogeneous across countries and time[4]. We can't, therefore, rely on these data to properly analyse how value-added is exchanged between countries. This has prompted the development of new methods to obtain better measures of trade in value-added.[5]

If we follow Koopman et al. (2014), for example, bilateral value-added exports are functions of the final goods exports of every country in the world for each bilateral relationship. In other words, bilateral value-added exports (v_{ij}) from country "i" to country "j" are obtained by summing up weighted final goods exports from every country $s \in S$ in the world to the importing country, where the weights are proportional to the importance of the origin country "i" in the production structure of the other countries ($s \in S$). S represents the set of countries in the world including "i". We exploit this definition to derive a gravity model for value-added exports, using the structural model of Anderson and Van Wincoop (2003) as a starting point. In appendix 6.A, we derive our model by posing a problem of maximisation under constraints, and we obtain the same results as in this section.

[4]See Johnson and Noguera (2012b)

[5]Daudin et al. (2011), Johnson and Noguera (2012a), Koopman et al. (2014)

More formally, we have:

$$v_{ij} = \left(\sum_{s=i}^{S} \pi_{is} X_{sj}\right) \tag{9}$$

Where X_{sj} is defined as in (1), π_{is} the fraction of country "i" value-added required to produce a unit of final goods in country s and v_{ij} bilateral value-added exports.

By combining equations (9) and (1), it follows that:

$$v_{ij} = \sum_{s=i}^{S} \frac{Y_s\ D_j}{Y_w} \left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma} \pi_{is}$$

$$= \left(\frac{Y_i\ D_j}{Y_w} \left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma} \pi_{ii}\right) + \left(\sum_{s\neq i}^{S} \frac{Y_s\ D_j}{Y_w} \left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma} \pi_{is}\right)$$

$$\Rightarrow v_{ij} = \left(\frac{Y_i\ D_j}{Y_w} \left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma} \pi_{ii}\right) \left(\frac{\frac{Y_i\ D_j}{Y_w} \left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma} \pi_{ii} + \sum_{s\neq i}^{S} \frac{Y_s\ D_j}{Y_w} \left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma} \pi_{is}}{\frac{Y_i\ D_j}{Y_w} \left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma} \pi_{ii}}\right)$$

$$= \left(\frac{Y_i\ D_j}{Y_w} \left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}\right) \left(\frac{\sum_{s=i}^{S} \frac{Y_s\ D_j}{Y_w} \left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma} \pi_{is}}{\frac{Y_i\ D_j}{Y_w} \left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}}\right)$$

$$= \left(\frac{Y_i\ D_j}{Y_w} \left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}\right) \left(\frac{\sum_{s=i}^{S} \pi_{is}\quad Y_s \left(\frac{t_{sj}}{\Pi_s}\right)^{1-\sigma}}{Y_i \left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma}}\right)$$

$$\Rightarrow v_{ij} = \left(\frac{Y_i\ D_j}{Y_w} \left(\frac{t_{ij}\ t_{iSj}}{\Pi_i\ P_j}\right)^{1-\sigma}\right) \tag{10}$$

$$\text{Where } t_{iSj} = \left(\frac{\sum_{s=i}^{S} \pi_{is}\quad Y_s \left(\frac{t_{sj}}{\Pi_s}\right)^{1-\sigma}}{Y_i \left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma}}\right)^{\frac{1}{1-\sigma}} \tag{11}$$

This term t_{iSj} is a function of bilateral trade costs between "i" and "j", and of the weighted sum of bilateral trade costs between "j" and all its trading partners including "i. It is also very similar to AVW multilateral resistance, except for the fact that it is associated with a bilateral relationship instead of being idiosyncratic to a country. It represents the relative trade cost of the indirectly exported value-added from the origin country "i" to the destination country "j" through third countries "$s \in S$" with respect to the directly exported value-added from "i" to "j". Besides, we can see that equation (10) is close to the Anderson and Van Wincoop's gravity equation with the difference that it is scaled by this new term that we label "Cost of fragmentation".

As bilateral trade costs, this term exerts a negative effect on bilateral value-added exports. However, it decreases with the amount of indirectly exported value-added by the origin country, that is to say, $\frac{\partial t_{iSj}}{\partial \pi_{is}} < 0$. It means that the more connected a country is to the world production network via its intermediate inputs' exports, the lesser its cost of fragmentation will be, and the higher will be its exported value-added to a given partner comparatively to a less connected country.

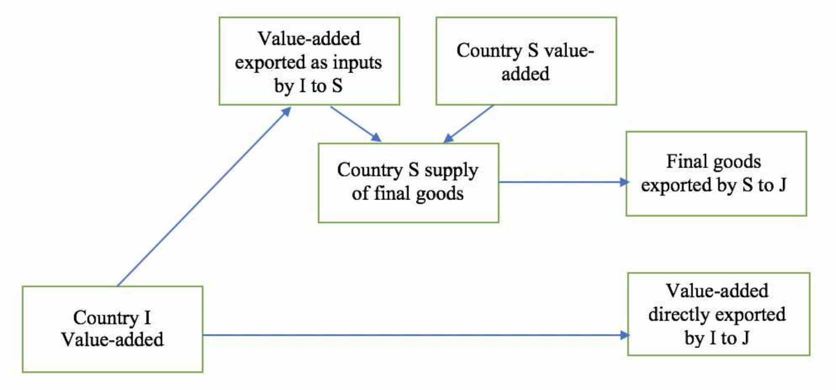


Figure 1: Schematic description of bilateral value-added exports

For example, consider a 3 countries case with countries "i", "s" and "j" as in the figure above. The exported value-added from "i" to "j" depends on its direct exports to "j", but also its indirect exports through country "s" final goods exports to "j".[6] This is because in order to produce a unit of final good, country "s" needs intermediate goods and thus value-added from "i". This example also clearly illustrates that the trade costs incurred by the exported value-added from "i" to "j" are not only direct trade costs, but also indirect trade costs incurred by the indirectly exported value-added via "s" final goods exports to "j".

Estimating a model of trade in value-added without taking into account these indirect trade costs, therefore, leads to an omitted variable bias with its undesirable consequences on the estimated coefficients. As it should be clear now, value-added exports are not common data on trade between countries easily available and should therefore be calculated. To do so, we need an inter-country or multi-country input-output matrix. The following section describes the data set used for this work.

[6]It should be recalled that B_{is} represents the total quantity of country "i" output required to produce a unit of final good in country "s", and that will be consumed either in "s" or outside "s". $B_{is}Y_s$ therefore, represents the fraction of country "i" output required to produce country "s" supply of final goods that will be consumed either in "s" or outside "s".

4 Data

Our work is based on the GTAP 9 database[7], which is a multi-country input-output table. This table comprises 57 sectors and 140 entities within which we find 26 African countries and 6 aggregated regions for the rest of Africa. The data set released in 2015 has 3 base years among which we choose 2011 to conduct our analysis. We obtained our measure of value-added exports using the methodology developed by Koopman et al. (2014). As our table is a multi-country table, imports of intermediate consumption are not broken down by countries of origin just as final demand imports. This poses a problem because we need the complete set of bilateral intermediate and final demand imports in order to calculate the bilateral value-added exports of each country. To solve this problem, two options are possible.

Firstly, we can apply a proportionality assumption. More precisely, we assume that for a given destination country, the imported share of intermediate goods from an origin country is the same as the share of this country in the total imports of the destination country. This assumption has been fairly criticised for its lack of realism.[8] The second option tackles some of these criticisms by relying on the UN Broad Economic Classification of products by end-use category with HS6 digits level COMTRADE data to split commodities into intermediate and final goods. Using the trade shares thereby obtained, a reconciliation exercise is conducted to ensure that the new set of intermediate and final goods flows be consistent with GTAP database aggregates. We use both options to get our data on value-added exports. In order to perform the reconciliation exercise mentioned in the second option, we follow Tsigas et al. (2012) who proposed a quadratic mathematical programming model to do so. Appendix 6.C provides more details.

As mentioned earlier, the input-output table level of aggregation is very high. It is problematic because of our focus on African countries. We just have 26 over 54 countries in the continent, the 28 other countries being represented by 6 aggregated regions. This implies that considerations regarding intra-African trade can't be analysed convincingly in this work. Besides, this level of aggregation forces us to make assumptions regarding some gravity variables such as "contiguity" or "common official language". In fact, if one country in an aggregation of countries shares a border with another one outside of the aggregated entity, it does not mean that all the entity shares a border with the said external country. We, therefore, need to take this into account and we arbitrarily consider that a given aggregation of countries shares a common border with a state if at least 80%

[7]This data base is available on the GTAP website.

[8]See for example Milberg and Winkler (2010), Puzzello (2012)

of its component countries share a border with it.

Table 1: Presentation of the different variables used in our estimations

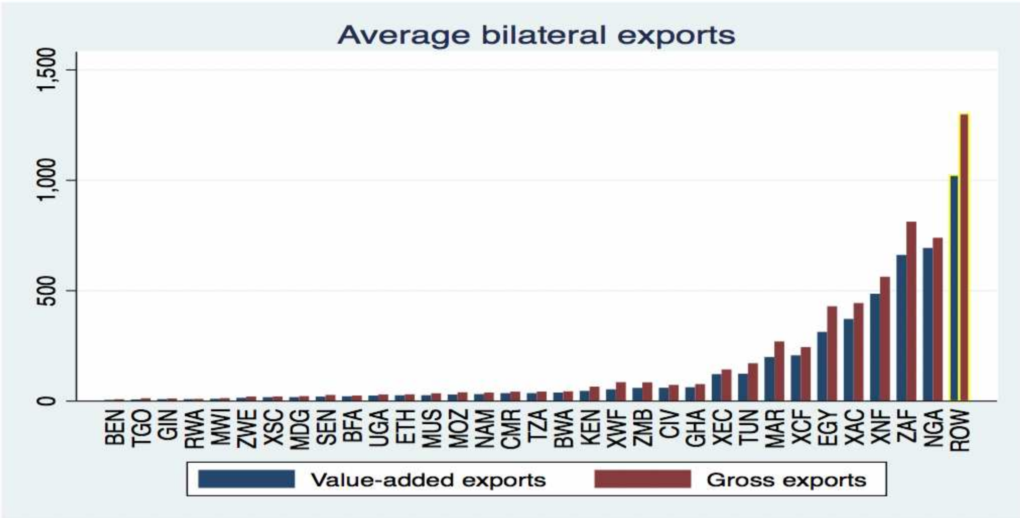
Variables	Source	Methodology/rule/formula
Value-added exports	Author calculations	Koopman Wang and Wei (2014)
Distance	American museum of natural history	Distance of an entity to itself: $d_{ii} = 0.33\sqrt{\frac{area}{\pi}}$
Contiguity	Cepii/Author calculations	
Common official language	Cepii/Author calculations	1 if 80% of the countries of an aggregated entity
Colony	Cepii/Author calculations	share the characteristic in the first column
Common colonizer	Cepii/Author calculations	with a given country, zero otherwise.
Regional trade agreement	Mario Larch	
Cost of fragmentation (t_{iSj})	Author calculations	$\left(\frac{\sum_{s=i}^{S} \pi_{is} \quad Y_s\left(\frac{t_{sj}}{\Pi_s}\right)^{1-\sigma}}{Y_i\left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma}}\right)^{\frac{1}{1-\sigma}}$

Table 1 presents some of the variables used in our estimations, their sources and the rules or methodology applied to get them. As we can see, we obtained the geographic distance between each pair of countries by using a generator built by the Centre for Biodiversity and Conservation of the American Museum of Natural History (AMNH), except for the distance of a country to itself calculated via the formula in column 3. The proxy for the cost of fragmentation is obtained as follows: we estimate equation (8) with the trade costs function in equation (6) to obtain the trade costs parameters that will allow us to get a proxy of final goods exports bilateral indexes of trade costs (${t_{ij}}^{1-\sigma}$). The exporter multilateral resistance $\Pi_i^{1-\sigma}$ is then obtained following Fally (2015) and finally, using equation (11), we solve for the cost of fragmentation.

It is important to note that with this procedure, we do not get t_{iSj}, but rather ${t_{iSj}}^{1-\sigma}$. This implies that the effect of the obtained term on value-added exports will not be $(1-\sigma)$ as it would have been the case if we were able to calculate t_{iSj} directly, but unity instead (at least theoretically). ${t_{iSj}}^{1-\sigma}$ is, therefore, more alike an inverse cost of fragmentation, and we label it like that thereafter. The econometric results will render it more explicit; however, before going to them, it would be interesting to make a quick description of the data on exports in value-added and gross terms and on the cost of fragmentation.

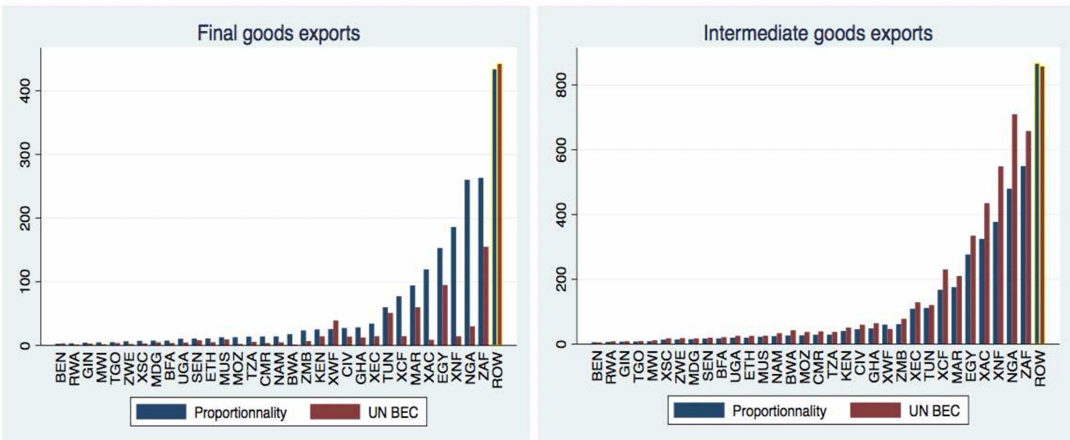
Figure 2 presents the average data on bilateral value-added and gross exports for African countries in comparison to the rest of the sample (ROW). It shows without surprise that the former's bilateral exports flows are lower in comparison to other countries be it for value-added exports or gross exports.

When we further disentangle gross exports between intermediate and final goods exports using either the proportionality assumption or the method based on the UN Broad Economic Classification of products by end-use category (UN BEC method thereafter), the result remains the same I.e. African exports flows are lower in comparison to other coun-



Source: Authors calculations, GTAP 9 database

Figure 2: African countries average bilateral exports (2011)

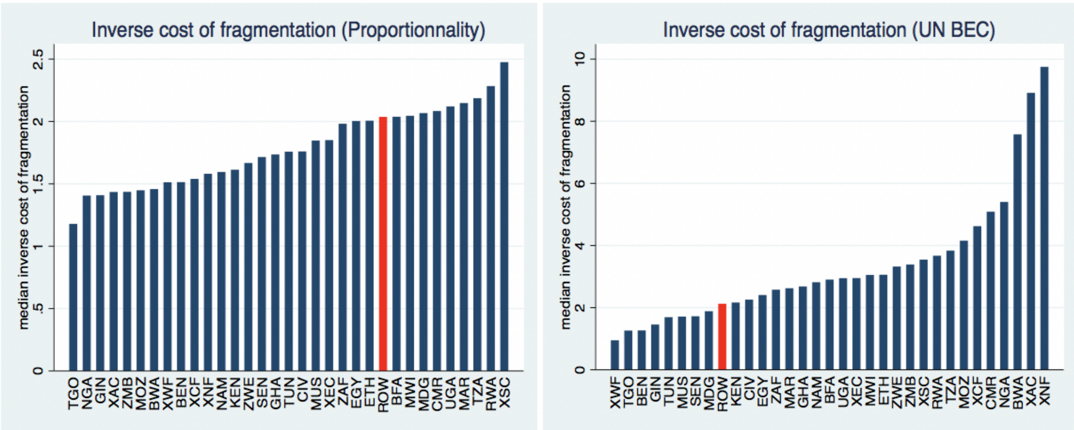


Source: Authors calculations, GTAP 9 database

Figure 3: African countries average bilateral exports by end use (2011)

tries as shown in chart 3. Interestingly, this figure also highlights a meaningful difference between trade flows obtained using the two different methods.

It appears that when the proportionality assumption is used, the average final goods export flow is higher for almost all African countries in the sample than when the UN BEC method is used. The contrary holds when it comes to intermediate goods exports. This suggests that the proportionality method is probably not able to replicate the true breakdown of gross exports between final and intermediate goods and that the UN BEC method at least captures some heterogeneity between the two kinds of flows.

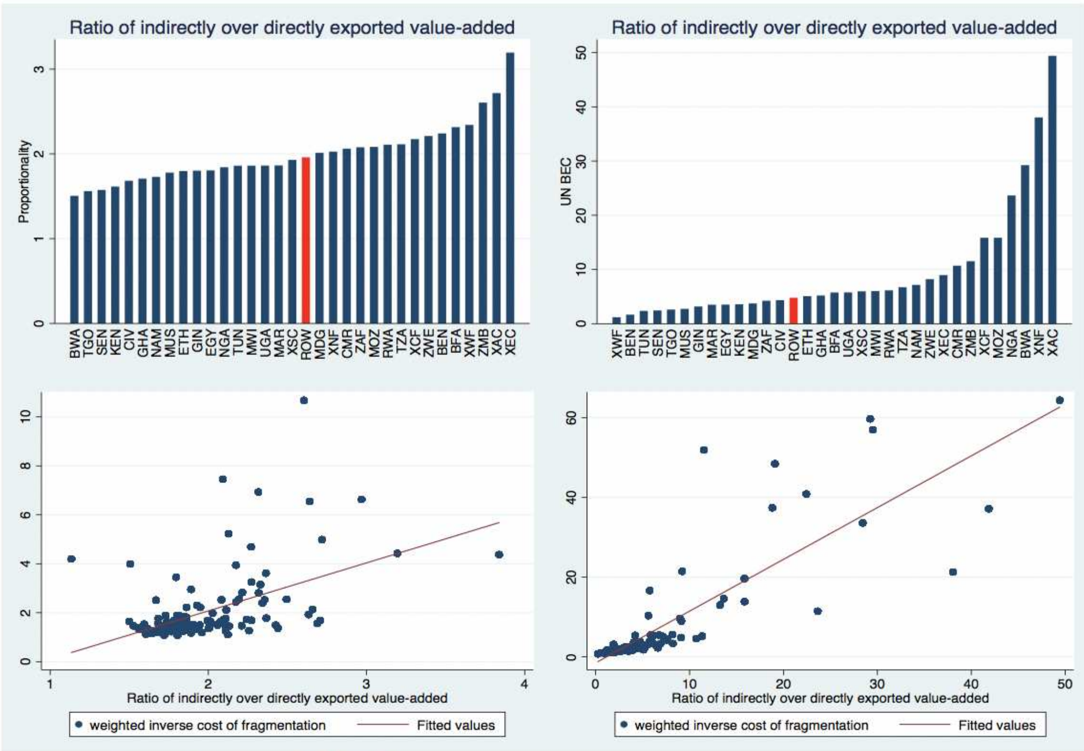


Source: Authors calculations, GTAP 9 database

Figure 4: African countries median inverse cost of fragmentation

As one could imagine, assessing African countries' Trade performance using flows obtained with the two methods could lead to different results. Either way, as regards the cost of fragmentation, the difference is attested. Figure 4 presents measures for the inverse cost of fragmentation (${t_{iSj}}^{1-\sigma}$) based upon flows obtained with the two methods. The chart shows that for most African countries (72%), the median inverse cost of fragmentation is lower in comparison to other countries when the proportionality method is used to get intermediate goods exports and higher when the second option is used. As mentioned earlier $\frac{\partial t_{iSj}}{\partial \pi_{is} \ Y_s} < 0$, and therefore, $\frac{\partial {t_{iSj}}^{1-\sigma}}{\partial \pi_{is} \ Y_s} > 0$ (where $\pi_{is} Y_s$ is the amount of value-added indirectly exported by country "i" through third country "s"). A higher inverse cost of fragmentation, I.e. lower cost of fragmentation, therefore, would mean that African countries export more indirectly their value-added than the rest of the set and inversely. The analysis of the mode by which African flows are exported in figure 5 gives ground to this assertion.

When the UN BEC method is used (the right upper panel of chart 5), African countries featuring a lower median inverse cost of fragmentation in comparison to other countries also export less indirectly their value-added. This is however less true when the proportionality method is used (the left upper panel of chart 5), as confirm the scatter plots in the lower panel of the chart between the ratios of indirectly over directly exported value-added obtained with both methods and weighted inverse costs of fragmentation[9]. The slope is clearly higher for the UN BEC method in comparison to the proportionality method, suggesting a higher correlation for the former.



Source: Authors calculations, GTAP 9 database

Figure 5: African countries trade flows' mode of export

5 Econometric results

This section is organized into two parts. Firstly, using the latest advances in the estimation of gravity models, we reassess the conclusions regarding the weakness of African countries' exports in comparison to countries with similar characteristics, then we evaluate the real role played by trade costs in the export performance of these countries.

[9]The weighted inverse cost of fragmentation is obtained as following for each country: $\sum_j \frac{v_{ij}}{Y_i}\, t_{iSj}{}^{1-\sigma}$

5.1 The alleged weakness of African countries exports

Numerous studies, as we said earlier, pointed out that African countries export less than others with similar characteristics[10]. Most of them rely on ordinary least squares in order to get their results. This poses a problem because as shown by Silva and Tenreyro (2006), this estimator is not consistent if the condition of homoskedasticity is not met, something more than likely in trade data. Besides some concerns can be raised regarding the way key variables of the model are approximated, notably the mass variables and the multilateral resistance terms. Since Baldwin and Taglioni (2006) at least, it is common in the literature to control for these variables by including exporter and importer fixed effects in the estimation. However, when the problem is to assess the trade performance of different states, it is difficult to do so with the presence of fixed effects because they capture a share of what we are interested in.

Most of the studies on African states trade performance, therefore, do not include them in their estimations, and the mass variables are controlled by the exporter's and importer's respective GDP_s. This is a problem because a country's gross exports include a share of value-added from other countries, unlike its GDP. When a state is well integrated into the world production network, for example, when the import content in its exports is important, GDP is not a good proxy for its size. This is because the foreign share in its exports is by definition a share of other countries GDP. As we can see, it could significantly alter the scores of trade performance for countries with high value-added to gross exports ratio as African countries. It is thus very interesting to determine whether the alleged weakness of African exports in comparison to the benchmark continues to exist when the gravity model is estimated properly.

The two following tables present the results of our estimations. The first, table 2, presents regressions with bilateral gross exports as the dependent variable with two different estimators, notably ordinary least squares (columns 1 and 2) and the Poisson pseudo maximum likelihood estimator (Columns 3 and 4). The four regressions also feature two different mass variables, the log of GDP (lgdp_exporter) for columns 1 and 3 and the log of total output (loutput) for columns 2 and 4. In each regression, we do not control for exporters' multilateral resistances but include importers' fixed effects along with different other variables to control for trade costs. By not including exporter fixed effects, we are able to capture a penalty regarding African exports that should be higher than with exporter fixed effects, as the latter would capture a share of what we are interested in.

Among these variables, we have bilateral distance (ldist), and dummies to control respec-

[10] Freund and Rocha (2011); Buys et al. (2006); Limao and Venables (2001)

Table 2: Explanation of bilateral gross exports

VARIABLES	(1) OLS Log of goods exports	(2) OLS Log of goods exports	(3) PPML Gross exports	(4) PPML Gross exports
lgdp_exporter	0.937***		0.831***	
	(0.00454)		(0.0138)	
loutput		0.950***		0.834***
		(0.00438)		(0.0128)
ldist	-0.730***	-0.724***	-0.719***	-0.698***
	(0.0129)	(0.0124)	(0.0335)	(0.0327)
contig	0.904***	0.901***	0.203**	0.224***
	(0.0620)	(0.0598)	(0.0791)	(0.0814)
comlang_off	0.382***	0.412***	0.240***	0.250***
	(0.0294)	(0.0284)	(0.0773)	(0.0762)
colony	0.382***	0.372***	-0.0520	-0.0172
	(0.0746)	(0.0719)	(0.0979)	(0.0962)
comcol	0.370***	0.387***	0.438***	0.451***
	(0.0356)	(0.0343)	(0.118)	(0.120)
rta	0.316***	0.281***	0.0987*	0.103*
	(0.0225)	(0.0217)	(0.0597)	(0.0579)
aftrade	-0.530***	-0.444***	-0.168**	-0.0757
	(0.0198)	(0.0192)	(0.0835)	(0.0883)
Constant	4.050***	3.138***	5.730***	4.878***
	(0.158)	(0.153)	(0.323)	(0.322)
Observations	19,321	19,321	19,321	19,321
R-squared	0.870	0.879		
Exporter FE	NO	NO	NO	NO
Importer FE	YES	YES	YES	YES
Border effect	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

tively for the trade within a country (border effect), for the existence of a common border (contig), a common official language (comlang_off), a colonial link (colony), a common colonizer (comcol), or the existence of a common trade agreement (rta). We also include a dummy that is equal to 1 for African countries' exports and 0 otherwise (aftrade) in order to check whether there is a penalty regarding their exports. As explained by Freund and Rocha (2011) with this specification clearly inconsistent with trade theory because of the absence of exporter fixed effects, the penalty regarding African exports should be at its highest level.

As the table shows, the African dummy coefficient is negative and significant at the 1 per cent threshold for the first two columns, whose results are obtained using ordinary least squares. Specifically, when the mass variable used is the exporter's GDP (column

1), African countries export approximately 41% less ($e^{-0.53} - 1 = -0.41$) than expected. However, when the proper mass variable is used, notably total output (column 2), this penalty decreases to 36 % ($e^{-0.44} - 1 = -0.36$). Freund and Rocha (2011) find a penalty of a comparable magnitude when they use a similar specification as ours (See footnote 12 in their article).

The results are nevertheless different when we use the Poisson pseudo maximum likelihood estimator. In column 3 using this estimator along with the exporter's GDP as the mass variable, African countries export only 15% ($e^{-0.168} - 1 = -0.15$) less than expected. However, when the proper mass variable is used, the penalty no longer exists since the African dummy coefficient is not significant anymore. Thus, the alleged weakness of African countries' exports depends on the estimator used.

The question that arises is to determine which estimator we should prefer. Following Silva and Tenreyro (2006), we perform a test to check whether the pattern of heteroskedasticity in the data satisfies the condition required for the consistency of ordinary least squares. This test presented in appendix 6.B shows that the OLS estimator is not suitable to perform our estimations[11]. Thus, we can conclude that African countries do not export less than expected as regards bilateral gross exports. It could be interesting to determine whether this result holds at a more refined level where we distinguish between final and intermediate goods.

Authors like Antràs and De Gortari (2017) have suggested that trade costs exert a more detrimental effect on downstream stages of production than on upstream stages. As the alleged weakness of African exports is generally explained by the higher level of trade costs that these countries face compared to others, it will not be surprising that their trade in intermediate goods suffers a lower penalty than their trade in final goods. The suggestive evidence is presented in table 3, where the estimations are performed using the PPML estimator. This table features 4 columns, the first two representing respectively regressions with intermediate goods and final goods exports obtained using the proportionality assumption, and the two following regressions with the dependent variables obtained using the UN BEC method mentioned above.

All these regressions follow the same econometric specification as in table 2 where we controlled for importer fixed effects and domestic trade but did not include exporter fixed effects. For each regression, the exporter mass variable (ltexport) is the sum of exports

[11]It is not necessary to perform the same test to determine whether the pattern of heteroskedasticity corresponds to that assumed by the PPML estimator because this estimator is consistent in our case even if the variance function is misspecified, unlike OLS. It may, however, not be efficient.

regarding the relevant trade flows. The variable of interest is again the African trade dummy equal to 1 for African exports and zero otherwise.

Table 3: Explanation of bilateral final and intermediate goods exports

VARIABLES	(1) PPML Intermediate goods exports	(2) PPML Final goods exports	(3) PPML Intermediate goods exports	(4) PPML Final goods exports
ldist	-0.677***	-0.699***	-0.649***	-0.798***
	(0.0348)	(0.0295)	(0.0386)	(0.0443)
contig	0.228**	0.276***	0.234**	0.206**
	(0.0918)	(0.0679)	(0.0956)	(0.0974)
comlang_off	0.265***	0.201***	0.308***	0.0800
	(0.0832)	(0.0665)	(0.0923)	(0.0870)
colony	0.0174	-0.0229	0.0408	-0.0405
	(0.0987)	(0.0999)	(0.104)	(0.133)
comcol	0.438***	0.467***	0.447***	0.385**
	(0.128)	(0.121)	(0.134)	(0.175)
rta	0.109*	0.101*	0.0655	0.232***
	(0.0620)	(0.0515)	(0.0650)	(0.0801)
aftrade	0.0227	-0.221***	0.0649	-0.730***
	(0.0946)	(0.0844)	(0.106)	(0.106)
ltexport1	0.829***			
	(0.0123)			
ltexport2		0.828***		
		(0.0149)		
ltexport3			0.770***	
			(0.0118)	
ltexport4				0.990***
				(0.0306)
Constant	4.821***	4.623***	5.377***	3.246***
	(0.343)	(0.286)	(0.364)	(0.417)
Observations	19,321	19,321	19,321	19,321
Exporter FE	NO	NO	NO	NO
Importer FE	YES	YES	YES	YES
Border effect	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As we can see, the African dummy coefficient is not significant for intermediate goods exports regardless of the way trade flows are obtained which means that as regards intermediate goods, African countries do not export less than expected. However, the story is different for final goods exports since they export 20 % less than expected ($e^{-0.221} - 1 = -0.198$) when the proportionality assumption is used, and 52% less ($e^{-0.73} - 1 = -0.518$) when the UN BEC method is used. This difference in magnitude stems directly from the proportionality assumption, which imposes that the trade shares be the same for final goods and intermediate goods imports in each country. Still, as the total value of exported goods is different from the total value of imported goods, we can assess the differential trade performance between final and intermediate goods exports for African countries.

Thus, according to this econometric specification, even if it is true that on average, African countries' aggregate bilateral trade is no less important than expected, it appears that when it comes to final goods, they underperform while it is not the case for intermediate goods. It should, however, be noted that this specification intentionally designed to reveal the highest penalty possible for African exports is not consistent with trade theory, as we do not take into account the exporters' multilateral resistances in our estimation.

To rigorously estimate the model, we need to control for these variables by including exporter fixed effects in the regressions. Doing so renders difficult the assessment of African countries' export performance because of perfect multicollinearity between the exporter fixed effects and the dummy for African exports. However, it is possible to check whether there is a difference between the impact of trade costs on these countries trade flows in comparison to others. In principle, a lower trade performance in comparison to a reference group should be reflected by higher trade costs or a higher impact of trade costs on trade flows.

Moreover, until now, we were interested in the export performance of African countries regarding their gross trade flows. Though, what is relevant for policymakers is not necessarily as said earlier, the growth of gross trade, as bilateral gross exports embed a share of value-added that comes from foreign countries. These exports could, therefore, increase because of an increase in this share of foreign value-added. Rather, value-added exports do not embed a foreign component and are only composed of local value-added. An increase in this variable thus has a direct impact on GDP growth, one of the core concerns of policymakers. In the next series of regressions, we examine whether trade costs have a higher impact on African countries bilateral gross exports and value-added exports.

5.2 Trade costs and African countries' trade performance

Many studies envisage high trade costs as one of the main explanations of Africa's Weak trade and economic performance.[12] We assess the relevance of this assertion by performing a series of regression based on theoretically consistent econometric specifications using the PPML estimator. The results are reported in tables 4 and 5. More precisely, we include exporter fixed effects along with importer fixed effects to control for exporters' and importers' multilateral resistances as requires theory. Consequently, we can no longer assess the trade performance of African countries by relying on the previous dummy variable equal to 1 for African exports and zero otherwise because of perfect multicollinearity.

Table 4: Additional impact of distance on African trade flows

VARIABLES	(1) PPML Gross exports	(2) PPML Final goods exports	(3) PPML Intermediate goods exports	(4) PPML Value-added exports	(5) PPML Final goods exports	(6) PPML Intermediate goods exports	(7) PPML Value-added exports
ldist	-0.689***	-0.682***	-0.692***	-0.729***	-0.695***	-0.692***	-0.711***
	(0.0323)	(0.0325)	(0.0325)	(0.0047)	(0.0437)	(0.0336)	(0.0130)
contig	0.265***	0.281***	0.260***	0.291***	0.297***	0.230***	0.304***
	(0.0699)	(0.0692)	(0.0713)	(0.01249)	(0.0949)	(0.0724)	(0.0350)
comlang_off	0.122*	0.126**	0.121*	0.136***	0.249***	0.0990	0.273***
	(0.0670)	(0.0613)	(0.0700)	(0.00968)	(0.0791)	(0.0738)	(0.0264)
colony	0.0695	0.101	0.0525	-0.01724	0.00763	0.103	-0.00817
	(0.0895)	(0.0908)	(0.0907)	(0.0129)	(0.113)	(0.0904)	(0.0343)
comcol	0.325**	0.363***	0.305**	0.385***	0.509***	0.256*	0.548***
	(0.131)	(0.133)	(0.134)	(0.0283)	(0.195)	(0.140)	(0.0554)
rta	0.176***	0.190***	0.175***	0.203***	0.213***	0.198***	0.222***
	(0.0551)	(0.0546)	(0.0562)	(0.00784)	(0.0732)	(0.0574)	(0.0206)
$lT_{iSj}{}^{1-\sigma}$				1.498***			1.142***
				(0.0145)			(0.0169)
afldist	-0.184*	-0.152	-0.205*	0.039**	-0.630***	-0.138	-0.0932***
	(0.108)	(0.117)	(0.106)	(0.0183)	(0.128)	(0.125)	(0.0285)
af2ldist	-0.123*	-0.150*	-0.109	-0.0316*	-0.0836	-0.138	-0.0371
	(0.0695)	(0.0812)	(0.0706)	(0.0177)	(0.0976)	(0.0851)	(0.0299)
Constant	19.23***	18.20***	18.79***	18.17***	18.35***	18.77***	18.37***
	(0.318)	(0.322)	(0.320)	(0.0469)	(0.443)	(0.327)	(0.134)
Observations	19,321	19,321	19,321	19,321	19,321	19,321	19,321
Exporter FE	YES	YES	YES	YES	YES	YES	YES
Importer FE	YES	YES	YES	YES	YES	YES	YES
Border effect	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Instead, we create two interaction variables, one between the previous dummy equal to one for African exports or zero otherwise and bilateral distance (afldist), and another one between bilateral distance and a dummy equal to 1 for African imports and zero

[12] Amjadi and Yeats (1995), Limao and Venables (2001), Freund and Rocha (2011), Bosker and Garretsen (2012)

otherwise (af2ldist). Doing so allows us to avoid perfect multicollinearity, but also allows us to determine whether the distance coefficient is significantly higher for African exports in comparison to imports or inversely. Except for this, the trade costs function remains the same as before as regards bilateral gross exports, including for intermediate and final goods exports. There is a difference though regarding value-added exports. Consistently with the model developed in section 3, a new variable that we labelled the inverse cost of fragmentation appears. This variable, as explained earlier, captures the sum of third countries' trade costs through which the value-added of an origin country passes to reach its final destination.

Columns 2, 3, and 4 present the results respectively for final goods exports, intermediate goods exports and value-added exports obtained under the proportionality assumption. The dependent variables in columns 5, 6 and 7 are obtained using the UN BEC method presented in appendix 6.C. Firstly, we can see in column 4 and 7 that ${lt_{iSj}}^{1-\sigma}$, the log of the inverse cost of fragmentation exerts a positive and significant impact on value-added exports. The positive sign here is due to the fact that as we said earlier, we are only able to obtain a proxy of[13] ${T_{iSj}}^{1-\sigma}$ instead of T_{iSj} which is the real cost of fragmentation. This is because $(1-\sigma)$, the trade elasticity is not readily observable. Had we used T_{iSj} that the impact would be negative and equivalent to the trade elasticity.

The second interesting result is that there is indeed a supplementary effect of distance regarding African bilateral gross exports (af1dist) and imports (af2ldist) in column 1, although the coefficients regarding the interaction variables are only significant at the 10% threshold. It is worth to note that the additional coefficient for imports is 30 % lower than that of exports (0.123<0.184). Intuitively, one would have expected both penalties to be of the same magnitude since the impediments affecting exports should symmetrically affect imports. This is not the case here, suggesting that a share of the additional distance coefficient regarding exports captures the weak preferences of foreign countries for African goods.

As for final and intermediate goods exports obtained with the proportionality assumption, we can see that the trade costs coefficients are approximately the same as in column 1. It is a consequence of this assumption which imposes that the import shares be the same for both flows. The magnitude of the additional distance coefficients also reflects this idea. When it comes to value-added trade flows, however (column 4), the result is different.

[13] To obtain ${T_{iSj}}^{1-\sigma}$ we firstly run a regression with final goods as the dependent variable using the PPML estimator with exporter and importer fixed effects in order to get the trade costs coefficients. We then solve for ${t_{ij}}^{1-\sigma}$ using the trade costs function in equation 5 and for the multilateral resistances $\Pi_i^{1-\sigma}$ and $P_j^{1-\sigma}$ using equations 11 and 12. Finally, we solve for ${T_{iSj}}^{1-\sigma}$ using equation 21.

It appears that in contrast to what was suggested for gross trade flows, the additional distance coefficients for exports is positive and significant at the 5 per cent threshold while it is 4 times lower for imports; meaning that African value-added trade flows are less sensitive to distance than gross trade flows.

This result shares some similarities with the findings of Noguera (2012), who shows that the trade cost elasticity for value-added exports is about two-thirds of that of gross exports. In our case, however, on average, the common distance coefficient is approximately the same be it for value-added exports or gross exports. Only the additional distance coefficients regarding African countries are different for both trade flows. This is due to the fact that the robust standard errors are lower when the dependent variable is expressed in value-added terms, suggesting that there is less heterogeneity across countries regarding the magnitude of the trade costs parameters.

For instance, in the case of distance, the robust standard error is equal to 0.00493 when the dependent variable is expressed in value-added terms (column 4), while it is equal to 0.0323 for gross exports (column 1). It is interesting to note that the results still hold when the dependent variables are obtained using the UN BEC method. We can see that the additional distance coefficient is twice lower regarding African value-added exports in comparison to gross exports[14], and non-significant regarding value-added imports (column 7). Also, the robust standard error regarding the distance coefficient is equal to 0.013 for the model with value-added exports, while it is equal to 0.0437 for final goods exports (column 5).

It is moreover worth to note that when the import shares are not constrained to be the same between final goods and intermediate goods flows, the additional distance coefficient as for African final goods exports -0.630 (column 4) is approximately 3 times higher than that of gross exports -0.184; whereas this coefficient is non-significant for final goods imports. In addition, as for intermediate goods, distance does not appear to play a differential impact for African trade flows in comparison to other countries. This finding seems to confirm the result found in table 3 that African countries underperform only with their final goods exports. It also suggests as argued earlier that a share of the additional distance coefficient regarding exports captures the preferences of foreign countries regarding African goods.

[14]We should note that it is more relevant to compare final goods trade costs coefficients and value-added trade costs coefficients because as shown in section 3, bilateral value-added exports depend on final goods exports of origin countries and third countries, and thus on final goods trade costs. However, as final goods exports in column 3 are obtained using the proportionality assumption, these trade costs are approximately the same as gross exports' trade costs. It is not the case when the proportionality assumption is not used.

We say so because intermediate goods are supposed to be more homogeneous than final goods. If distance does not affect more African final goods imports nor intermediate goods flows but only affects more final goods exports that are highly heterogeneous across countries, it is likely that this penalty is, in fact reflecting other countries' weak preferences for African final goods. As the additional distance coefficient for value-added exports -0.0932 in (column 7) is 7 times lower than that of final goods exports and 2 times lower than that of gross exports; this could suggest that preferences are different for gross trade flows and value-added trade flows.

The results reported in table 4 only quantify the additional impact of distance on African trade flows. In table 5, we perform the same regressions using the full bilateral trade costs indexes. More precisely, using equation (6), and the trade costs parameters obtained using the previous regressions without the interaction variables between distance and the dummies respectively for African exports (af1dist) and imports (af2ldist), we calculate the trade costs indexes ${t_{ij}}^{1-\sigma}$. We then create two new interaction variables respectively between the dummies for African exports and imports and the trade costs indexes in order to determine whether the impact of trade costs is higher for African trade flows than for others.

Table 5: Additional impact of trade costs on African trade flows

VARIABLES	(1) Gross exports	(2) Final goods exports	(3) Intermediate goods exports	(4) Value-added exports	(5) Final goods exports	(6) Intermediate goods exports	(7) Value-added exports
${lt_{ij}}^{1-\sigma}$	0.997***	0.996***	0.997***	1.000***	0.992***	1.016***	0.997***
	(0.0233)	(0.0229)	(0.0239)	(0.00357)	(0.0334)	(0.0231)	(0.0109)
${AFl_{ij}}^{1-\sigma}$	0.248*	0.196	0.282**	-0.0458**	0.736***	0.133	0.114***
	(0.132)	(0.140)	(0.131)	(0.0212)	(0.143)	(0.177)	(0.0318)
${AF2lt_{ij}}^{1-\sigma}$	0.149	0.182*	0.126	0.0391**	0.0882	0.188	0.0481
	(0.0907)	(0.105)	(0.0918)	(0.0205)	(0.116)	(0.114)	(0.0330)
${lT_{iSj}}^{1-\sigma}$				1.499***			1.142***
				(0.0145)			(0.0168)
Constant	19.30***	18.27***	18.84***	18.18***	18.39***	18.99***	18.38***
	(0.170)	(0.164)	(0.174)	(0.0293)	(0.253)	(0.171)	(0.0802)
Observations	19,321	19,321	19,321	19,321	19,321	19,321	19,321
Exporter FE	YES	YES	YES	YES	YES	YES	YES
Importer FE	YES	YES	YES	YES	YES	YES	YES
Border effect	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In table 5, $lt_{ij}^{1-\sigma}$ is the log of bilateral costs to trade between countries "i" and "j" taken to the power $1-\sigma$. $AFlt_{ij}^{1-\sigma}$ is an interaction variable between the dummy for African exports and $lt_{ij}^{1-\sigma}$, $AF2lt_{ij}^{1-\sigma}$ is an interaction variable between the dummy for African imports and $lt_{ij}^{1-\sigma}$ and ${lt_{iSj}}^{1-\sigma}$is the log of the inverse cost of fragmentation. Since $1-\sigma$ is negative, $lt_{ij}^{1-\sigma}$is inversely proportional to the level of trade costs.

As the reported results show, the previous conclusions still hold. Trade costs exert a higher impact on African countries gross exports in comparison to other countries. This is because as shown in column 1, a 1% increase in trade costs would decrease African gross exports by approximately $1-\sigma$ (0.997+0.248) %. When it comes to value-added exports, however, it appears as in the previous table that African value-added trade flows are less sensitive to trade costs than gross trade flows. When the proportionality assumption is used (column 4), trade costs exert a lower impact on African value-added exports in comparison to other countries since a 1% increase in trade costs would decrease African flows by $1-\sigma$(1.001-0.0458) % only. This is a lower figure than the impact on gross exports if we assume the trade elasticity to be the same for the two kinds of flows.

When the UN BEC method is used (column 7), the additional impact of trade costs on value-added exports "0.114" is at least twice lower when we compare it to the impact on gross exports and 6 times lower when we compare it to the impact on final goods exports (column 5). More interestingly, as in the previous table, when the UN BEC method is used, there is no additional impact of trade costs on African countries intermediate goods exports and imports (column 6). It is also the case for their imports of final goods so that only final goods exports are affected by an additional impact of trade costs. We observe the same thing as regards value-added exports (Column 7) and gross exports (column 1).

As explained earlier, this fact suggests that the weakness of African exports and especially final goods exports as established in table 3 is probably more due to weak preferences from Non-African countries regarding the goods of our countries of interest than to the higher trade costs faced by them. Also, value-added trade flows appear to be less impacted by these weak preferences, which implies that the export trade performance of our countries of interest is higher in value-added terms than in gross terms.

6 Concluding remarks

The goal of this paper was to question the quasi consensus in the literature on the weakness of African exports compared to what they should be. We find that the results are more ambiguous. By applying the latest advances in the estimation of international trade flows, we firstly showed that depending on the estimator used, African gross exports were not as weak as said in the literature in comparison to a gravity model benchmark. More precisely, we showed that even though they underperform clearly regarding their final goods exports, it is not the case as regards intermediate goods exports so that on average their gross exports' trade performance is similar to other countries.

We also showed that trade costs exert a higher impact on African countries trade flows, and especially their final goods exports. However, surprisingly, when the chosen dependent variable is not expressed in gross terms but rather in value-added terms, the additional impact of trade costs is at least two times lower compared to their impact on gross exports and even 6 times lower compared to their impact on final goods exports. African value-added exports are thus less sensitive to trade costs than gross trade flows.

Finally, we observed that the additional impact of trade costs mostly concerns exports, since it is either less important or non-existent as regards imports. This differential impact of trade costs to us suggests that when it exists, the weakness of African exports is probably more due to weak preferences from other countries on African goods than on the higher level of trade costs they face compared to others as asserted in the literature.

Either way, be it weak preferences or trade costs, the trade flows that should matter the most for policymakers, value-added exports are apparently less sensitive to these impediments than gross trade flows. It appears, however, that countries that are well integrated into the global value chain are likely to export more value-added than others. It could thus be interesting to assess the interaction between trade costs and participation in the global value chain and determine up to which extent trade costs should decrease to foster the participation of a given region significantly.

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6.A Derivation of the value-added exports gravity model (Maximisation under constraints)

We have the following expression for value added-exports coming from Koopman et al. (2014):

$$v_{ij} = n_i(\sum_{s=i}^{S} B_{is}X_{sj}) \tag{12}$$

Where v_{ij} represents the exported value added from the origin country "i" to the destination country "j". This expression is obtained using input-output analysis by decomposing a given country gross exports in terms of region of origin. As we know, to produce a unit of exported final good, a country needs inputs from other regions in the world on top of its own inputs. The sum of these inputs value with the value of the final good to be exported represents gross exports, and the exported value added is, therefore, the share of gross exports that has been created in the origin country uniquely. Said alternatively, it represents the payments made to workers and capital owners in the origin country to produce the exported good. In this expression, $n_i = \frac{Y_i}{G_i}$ represents the GDP (Y_i) to total output (G_i) ratio, B_{is} is an element of the total requirement matrix derived via input output analysis. It represents the amount of country "i" goods required to produce a unit of final goods in country s that will be consumed either in "s" or abroad. Finally, X_{sj} represents the final goods exports from country "s" to country "j".

Equation (12) can be rewritten like this:

$$v_{ij} = n_i(B_{ii}X_{ij} + \sum_{s \neq i}^{S} B_{is}X_{sj}) \tag{13}$$

By rewriting the equation like this, we show that the exported value-added from country i to country j depends on the directly exported value-added by "i" to "j" ($B_{ii}X_{ij}$), and on the indirectly exported value-added from i, via third states "s" to country j ($\sum_{s \neq i}^{S} B_{is}X_{sj}$). This indirectly exported value added, is nothing more than the intermediate goods sourced from "i" that are embedded, in the final good exports of third countries s, to the destination country j.

Unlike classic exports flows, we see that value-added exports have a more complex structure, and this should be taken into account in order to build a rigorous gravity model. If we denote by c_{ij} country j consumption of final goods (quantity) from country i, and $\alpha_{is} = n_i \ B_{is}$ the amount of value-added from country "i" required to produce a unit of final good in country s, the utility function to be maximized by country j consumers is thus:

$$\left(\sum_{i} \sum_{s=i}^{S} \beta_s^{\frac{1-\sigma}{\sigma}} \ (\alpha_{is}\ c_{sj})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{14}$$

Subject to the budget constraint:

$$\sum_{i} \sum_{s=i} \alpha_{is}\ c_{sj}\ p_{sj} = Y_j \tag{15}$$

Where $p_{sj} = \ p_s t_{sj}$ is the price of the exported good from country s to country j composed of the supply price of the exporting country "p_s", and trade cost factor between the two countries "t_{sj}". $c_{sj}\ p_{sj}$ therefore, represents the nominal value of the exported final good from s to j.

We solve this problem for the bilateral relationship "ij" by posing the Lagrangian:

$$L = \left(\sum_{i} \sum_{s=i}^{S} \beta_s^{\frac{1-\sigma}{\sigma}} \ (\alpha_{is}\ c_{sj})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} - \lambda \left(\sum_{i} \sum_{s=i} \alpha_{is}\ c_{sj}\ p_{sj} - Y_j \right) \tag{16}$$

$\frac{\partial L}{\partial \alpha_{is}\ c_{sj}} = 0$

$$\Rightarrow \frac{\sigma}{\sigma-1} \left(\sum_{i} \sum_{s=i}^{S} \beta_s^{\frac{1-\sigma}{\sigma}} \ (\alpha_{is}\ c_{sj})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{1}{\sigma-1}} \beta_s^{\frac{1-\sigma}{\sigma}} \ \frac{\sigma-1}{\sigma} (\alpha_{is}\ c_{sj})^{\frac{-1}{\sigma}} - \lambda p_{sj} = 0 \tag{17}$$

$$\Rightarrow \frac{\left(\sum_{i} \sum_{s=i}^{S} \beta_s^{\frac{1-\sigma}{\sigma}} \ (\alpha_{is}\ c_{sj})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{1}{\sigma-1}} \beta_s^{\frac{1-\sigma}{\sigma}} \ (\alpha_{is}\ c_{sj})^{\frac{-1}{\sigma}}}{p_{sj}} = \lambda$$

$$\Rightarrow (\alpha_{is}\ c_{sj})^{\frac{-1}{\sigma}} = \frac{\lambda p_{sj}}{\left(\sum_{i} \sum_{s=i}^{S} \beta_s^{\frac{1-\sigma}{\sigma}} \ (\alpha_{is}\ c_{sj})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{1}{\sigma-1}} \beta_s^{\frac{1-\sigma}{\sigma}}}$$

$$\Rightarrow \alpha_{is}\ c_{sj} = \left(\frac{\lambda p_{sj}}{\left(\sum_{i} \sum_{s=i}^{S} \beta_s^{\frac{1-\sigma}{\sigma}} \ (\alpha_{is}\ c_{sj})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{1}{\sigma-1}} \beta_s^{\frac{1-\sigma}{\sigma}}} \right)^{-\sigma}$$

We pose $\left(\sum_i \sum_{s=i}^{S} \beta_s^{\frac{1-\sigma}{\sigma}} \ (\alpha_{is}\ c_{sj})^{\frac{\sigma-1}{\sigma}}\right)^{\frac{1}{\sigma-1}} = \text{A and } \ c_{sj}\ p_{sj} = \ x_{sj}$

$\Rightarrow \alpha_{is}\ x_{sj} = \frac{\lambda^{-\sigma}}{A^{-\sigma}} (\beta_s\ p_s t_{sj})^{1-\sigma}$ with $p_s t_{sj} = p_{sj}$

We thus have: $\sum_{s=i}^{S} \alpha_{is}\ x_{sj} = \frac{\lambda^{-\sigma}}{A^{-\sigma}} \sum_{s=i} (\beta_s\ p_s t_{sj})^{1-\sigma}$

$$\Rightarrow \alpha_{is}\ x_{sj} = \frac{(\beta_s\ p_s t_{sj})^{1-\sigma}}{\sum_{s=i}^{S} (\beta_s\ p_s t_{sj})^{1-\sigma}} \left(\sum_{s=i}^{S} \alpha_{is}\ x_{sj}\right) \tag{18}$$

We also have $\sum_i \alpha_{is}\ x_{sj} = \frac{(\beta_s\ p_s t_{sj})^{1-\sigma}}{\sum_{s=i}^{S} (\beta_s\ p_s t_{sj})^{1-\sigma}} \left(\sum_i \sum_{s=i}^{S} \alpha_{is}\ x_{sj}\right)$

$= \frac{(\beta_s\ p_s t_{sj})^{1-\sigma}}{\sum_{s=i}^{S} (\beta_s\ p_s t_{sj})^{1-\sigma}} Y_j$

This finally gives:

$$\alpha_{is}\ x_{sj} = \left(\frac{\beta_s\ p_s t_{sj}}{P_j}\right)^{1-\sigma} \frac{\alpha_{is}}{\sum_i \alpha_{is}} Y_j \tag{19}$$

$$\text{Where} \quad P_j = \left[\sum_{s=i}^{S} (\beta_s\ p_s t_{sj})^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{20}$$

As Anderson and Van Wincoop (2003) we impose market clearance to derive the gravity equation. This implies:

$$Y_s = \sum_i \sum_j \alpha_{is}\ x_{sj} \tag{21}$$

Knowing that $\sum_i \alpha_{is}$ equals 1, and where Y_s represents the total income of country s.

We thus have:

$$Y_s = \sum_j \left(\frac{\beta_s\ p_s t_{sj}}{P_j}\right)^{1-\sigma} \sum_i \frac{\alpha_{is}}{\sum_i \alpha_{is}} Y_j \tag{22}$$

$= \sum_j \left(\frac{\beta_s\ p_s t_{sj}}{P_j}\right)^{1-\sigma} Y_j$

We also solve for the scaled price $\beta_s p_s$ as (AVW) which gives:

$(\beta_s p_s)^{1-\sigma} = \frac{Y_s}{\sum_j \left(\frac{t_{sj}}{P_j}\right)^{1-\sigma} \frac{Y_j}{Y_W}}$

Replacing this in equation (19), we obtain:

$$\alpha_{is}\ x_{sj} = \frac{Y_s\ Y_j}{Y_w}\left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma}\frac{\alpha_{is}}{\sum_i \alpha_{is}} \tag{23}$$

Where $\Pi_s = \left[\sum_j \left(\frac{t_{sj}}{P_j}\right)^{1-\sigma}\ \frac{Y_j}{Y_w}\right]^{\frac{1}{1-\sigma}}$ and $P_j = \left[\sum_{s=i}^{S}\left(\frac{t_{sj}}{\Pi_s}\right)^{1-\sigma}\ \frac{Y_s}{Y_w}\right]^{\frac{1}{1-\sigma}}$

As mentioned earlier, the bilateral exported value-added from country "i" to "j" is:

$v_{ij} = \left(\sum_{s=i}^{S}\alpha_{is}X_{sj}\right)$ with $\alpha_{is} = n_i\ B_{is}$ and $n_i = \frac{Y_i}{G_i}$

It follows that:

$$v_{ij} = \sum_{s=i}^{S}\frac{Y_s\ Y_j}{Y_w}\left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma}\frac{\alpha_{is}}{\sum_i \alpha_{is}}$$

$$= \left(\frac{Y_i\ Y_j}{Y_w}\left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}\alpha_{ii}\right) + \left(\sum_{s\neq i}^{S}\frac{Y_s\ Y_j}{Y_w}\left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma}\frac{\alpha_{is}}{\sum_i \alpha_{is}}\right)$$

$$\Rightarrow v_{ij} = \left(\frac{Y_i\ Y_j}{Y_w}\left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}\alpha_{ii}\right)\left(\frac{\frac{Y_i\ Y_j}{Y_w}\left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}\alpha_{ii} + \sum_{s\neq i}^{S}\frac{Y_s\ Y_j}{Y_w}\left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma}\frac{\alpha_{is}}{\sum_i \alpha_{is}}}{\frac{Y_i\ Y_j}{Y_w}\left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}\alpha_{ii}}\right)$$

$$= \left(\frac{Y_i\ Y_j}{Y_w}\left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}\right)\left(\frac{\sum_{s=i}^{S}\frac{Y_s\ Y_j}{Y_w}\left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma}\frac{\alpha_{is}}{\sum_i \alpha_{is}}}{\frac{Y_i\ Y_j}{Y_w}\left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}}\right)$$

$$= \left(\frac{Y_i\ Y_j}{Y_w}\left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}\right)\left(\frac{\sum_{s=i}^{S}\beta_{is}\quad Y_s\left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma}}{G_i\ \left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}}\right)$$

This equation is equivalent to the previous equation (10) (in the main text) and could be rewritten like this:

$$= \left(\frac{Y_i\ Y_j}{G_i\ Y_w}\right)\left(\sum_{s=i}^{S}\beta_{is}\quad Y_s\ \left(\frac{t_{sj}}{\Pi_s\ P_j}\right)^{1-\sigma}\right) \text{ or}$$

$$= \left(\frac{Y_i\ Y_j}{Y_w}\left(\frac{t_{ij}}{\Pi_i\ P_j}\right)^{1-\sigma}\right)\left(\sum_{s=i}^{S}\frac{\beta_{is}\quad Y_s}{G_i}\ \left(\frac{\frac{t_{sj}}{t_{ij}}}{\frac{\Pi_s}{\Pi_i}}\right)^{1-\sigma}\right)$$

Recalling that $\sum_i \alpha_{is} = 1$ and $\alpha_{is} = \frac{Y_i}{G_i}B_{is}$.

6.B Test of the pattern of heteroskedasticity

In order to test the appropriateness of each estimator to our data, we followed Silva and Tenreyro (2006). As each estimator assumes a specific pattern of heteroskedasticity, their efficiency thus depends on how the variance of the dependent variable relates to its expected value. We have the following general case suggested by Manning and Mullahy (2001):

$V[Y_i|X_i] = \lambda_0 E[Y_i|X_i]^{\lambda_1}$

If $\lambda_1 = 1$, then Poisson PML is efficient. This case is a generalization of the Poisson variance assumption that is to say equality between the conditional variance and the conditional mean. If $\lambda_1 = 2$, the Gamma PML is the optimal PML estimator. As we know the Gamma PML first order conditions are close to the OLS (on logs) first order conditions. The OLS estimator is also consistent in this case.

The results are presented in table 6[15]. These tests have been conducted with conditional variance proxies obtained from the estimations presented in table 2 columns 2 and 4 in the main document. Specifically, we estimated for the OLS case using a non-robust covariance estimator:

$$\ln\left(Export_{ij} - \widehat{Export}_{ij}\right)^2 = \ln\lambda_0 + \lambda_1 \ln\left(\widehat{Export}_{ij}\right) + v_{ij} \tag{24}$$

and for the PPML case using a robust covariance matrix estimator.

$$\left(Export_{ij} - \widehat{Export}_{ij}\right)^2 = \lambda_0 \widehat{Export}_{ij} + \lambda_0\left(\lambda_1 - 1\right)\ln\left(Export_{ij}\right)\widehat{Export}_{ij} + e_{ij} \tag{25}$$

For the OLS case, we tested the null hypothesis $\lambda_1 = 2$, and for the PPML case $\lambda_0(\lambda_1 - 1) = 0$.

Table 6: Results of the test on the type of heteroskedasticity in the data (p-values)

Test (null hypothesis)	OLS (table 2 column 2)	PPML (Table 2 column 4)
P-value	0.0000	0.300

As we can see, this test gives credit to the adequacy of the PPML estimator to our data, and thus reinforces the credibility of our results.

[15]See Silva and Tenreyro (2006) for more details on the tests

6.C Value-added exports methodology of obtention

In this appendix, we describe the methodology used to get value-added exports data. We begin by presenting the framework of Koopman et al. (2014) used to obtain these data and which is based upon input-output analysis. Then, we describe the database upon which this work is based, and finally, we present the two techniques used in order to disentangle gross exports between final goods and intermediate goods exports, a requirement to carry out our analysis.

6.C.1 Breakdown of gross exports by value-added from different origins

Input output analysis is a method of economic forecasting developed by Wassily Leontief, who received the Nobel Prize in economics in 1973. This method is founded on Input-Output Tables, which summarize the operations of sales and purchases that occurred within an economy by sector and by buyer or seller. To carry out the analysis, some strong assumptions are required:

- The constancy of intersectoral technical coefficients, which implies that an increase in production necessarily leads to a proportional increase in the inputs used throughout the production process. (No scale economies).
- Unrestricted availability of production factors
- Absence of substitutability between production factors, which implies that no matter their price or quantity, the share of capital or labour or even intermediate inputs remains the same in a unit of production. The production technology is therefore the same in the period of analysis, at least for static models.

The input output table is presented as following: the sales are listed from the left to the right in lines, and the purchases in columns.[16] We therefore have in lines:

$$g_i = \sum_{j=1}^{n} a_{ij} g_j + x_i \tag{26}$$

Where g_i represents the total production of sector i or the set of goods sold to satisfy sector i final demand (x_i) and demand in intermediate goods ($a_{ij}g_j$), a_{ij} the technical coefficient which represents sector i units of intermediates goods used in the production of sector j output. The technical coefficients constancy assumption thus means that for any sector j, the intermediate consumption/production ratio does not vary no matter the

[16] See Miller and Blair (2009)

production volume. In this framework, final demand is assumed to be exogenous since it does not depend on total production unlike intermediate consumption.

We have in columns:

$$g_j = \sum_{i=1}^{n} a_{ij} g_j + p_i \tag{27}$$

Where g_j represents the total production of sector j or the purchases of intermediate consumptions $(a_{ij} g_j)$ and other production factors such as labour or capital (p_i) necessary to produce the goods. By writing equation 1 for all sectors, we get in matrix notation:

$$g = Ag + x \quad \text{Where} \quad g = (I - A)^{-1} x = Lx \tag{28}$$

With A corresponding to a (n*n) matrix of technical coefficients, I the (n*n) identity matrix, $(I - A)^{-1} = L$ the Leontief inverse, g the production of each sector and x the corresponding final demand. As we are interested in relationships between several regions, a simple input output framework is not suitable since it simply shows the interdependencies between sectors of a single economy. We therefore need to use a different framework which is called Inter-regional input output table (IRIO) and which allows us to identify the interdependencies between the different regions studied and their industries. Technically, the methodology used to build it is roughly the same as the previous. For example, in a simple 2 regions (i,j) and 1 sector case, we would have for the sales (in line) :

$$g^i = a^{ii} g^i + a^{ij} g^j + x^{ii} + x^{ij} \tag{29}$$

With a^{ii} representing the units of intermediates goods used in the production of one unit of output in country i, a^{ij} country i units of intermediates goods used in the production of one unit of output in country j, x^{ii} country i production destined for the satisfaction of its own final demand, and x^{ij} country i production destined for the satisfaction of country j final demand.

In matrix form we have the same expression as equation (28) which gives an IRIO model as follows[17]:

$$\begin{bmatrix} g^{11} & g^{12} \\ g^{21} & g^{22} \end{bmatrix} = \begin{bmatrix} I - a^{11} & -a^{12} \\ -a^{21} & I - a^{22} \end{bmatrix}^{-1} \begin{bmatrix} x^{11} & x^{12} \\ x^{21} & x^{22} \end{bmatrix} = \begin{bmatrix} b^{11} & b^{12} \\ b^{21} & b^{22} \end{bmatrix} \begin{bmatrix} x^{11} & x^{12} \\ x^{21} & x^{22} \end{bmatrix} \tag{30}$$

[17]This part is mainly inspired from Koopman et al. (2014)

In this matrix, the countries' output is broken down by place of absorption. For example, country 1 output ($g^1 = g^{11}+g^{12}$) is equal to the output produced and consumed at home (g^{11}) and the output produced at home and consumed abroad g^{12} . Similarly, final demand is broken down by place of absorption with the total final demand of country 1 ($x^1 = x^{11} + x^{12}$) being equal to the final demand produced and consumed at home x^{11} and the final demand produced at home and consumed abroad x^{12}.

The matrix of b^{ij} is the matrix of "total requirement coefficients"[18]. For source country i and destination country j, b^{ij} represents the total amount of country i gross output required to produce an extra unit of final good in country j that can be consumed either in j or in i. By multiplying each coefficient of this matrix with the value-added share of gross output for the corresponding source country v^i, we get a (2*2) matrix of coefficients $v^i b^{ij}$ representing the total amount of country i value-added or GDP required to produce an extra unit of final good in country j that can be consumed either in j or in i. This formula allows us to disentangle a given country production into value added from different origins, either home or abroad.

Going back to equation (30), we can for example easily break down a unit of production in destination country 1 (the first column) into its own value-added $v^1 b^{11}$ and the value added coming from abroad $v^2 b^{21}$. Thus $v^2 b^{21}$ is nothing more than the imported value-added share in country 1 production, and given the assumption that exports and domestic sales use the same intensity of imported output generally made in the literature, we can also interpret this expression as the value-added import content of one unit of export. With this framework set, we can easily break down a country's gross exports, and therefore explain the discrepancy between the latter and its exports of value added.

As mentioned by Koopman et al. (2014), this allows us to identify the place of each country in the global or regional value chain.

We firstly rewrite country 1 and country 2 output as following:

$$g^1 = [g^{11} + g^{12}] = [x^{11} + a^{11}g^1 + (x^{12} + a^{12}g^2)] = [((1 - a^{11})^{-1}x^{11}) + ((1 - a^{11})^{-1}e^{12}] \quad (31)$$

Where $e^{12} = x^{12}+a^{12}g^2$ represents bilateral gross exports from country 1 to country 2.

$$g^2 = [g^{22} + g^{21}] = [x^{22} + a^{22}g^2 + (x^{21} + a^{21}g^1)] = [((1 - a^{22})^{-1}x^{22}) + ((1 - a^{22})^{-1}e^{21}] \quad (32)$$

Where $e^{21} = x^{21}+a^{21}g^1$

[18]See Koopman et al. (2014)

With these expressions, we can further break down country 1 exports by source of origin. Using $v^1b^{11} + v^2b^{21} = 1$, we therefore obtain:

$$e^{12} = (v^1b^{11} + v^2b^{21})(x^{12} + a^{12}g^2) = v^1b^{11}x^{12} + v^1b^{11}a^{12}g^2 + v^2b^{21}x^{12} + v^2b^{21}a^{12}g^2 \quad (33)$$

$$= v^1b^{11}x^{12}+v^1b^{12}x^{22} + v^1b^{12}x^{21} + v^1b^{12}a^{21}g^1 + v^2b^{21}x^{12} + v^2b^{21}a^{12}g^2$$

Where $v^1b^{11}a^{12}g^2 = \; v^1b^{12}x^{22} + +v^1b^{12}x^{21} + v^1b^{12}a^{21}g^1$

This equation simply means that country 1 total value of gross exports can be broken down in terms of value added by place of origin. We therefore have four terms, with the first representing the value added exported from country 1 to country 2 destined to satisfy the latter country demand in final goods ($v^1b^{11}x^{12}$). The second term represents the value added exported by country 1 and which is used as intermediate goods by country 2 to produce its final goods ($v^1b^{11}a^{12}g^2$). This term can be further broken down into intermediate exports that are absorbed in country 2 ($v^1b^{12}x^{22}$) and intermediate exports that are exported back to country 1 either within country 2 exports of final goods $v^1b^{12}x^{21}$ or within country 2 exports of intermediate goods $v^1b^{12}a^{21}g^1$.

The third term ($v^2b^{21}x^{12}$) represents the value added imported by country 1 and which is embodied in its exports of final goods to country 2, and the last term represents the value added imported by country 1 and which is embodied in its exports of intermediate goods to country 2. On this basis, we can obtain a complete breakdown of country 1's exports by highlighting the terms that are doubly counted, and that explain the gap between value-added exports and gross exports. We do this by combining the three previous equations, which gives the following expression:

$$\begin{aligned} e^{12} &= [v^1b^{11}x^{12} + v^1b^{12}x^{22}] + [\; v^1b^{12}x^{21} + v^1b^{12}a^{21}(1-a^{11})^{-1}x^{11}] \\ &+ v^1b^{12}a^{21}(1-a^{11})^{-1}e^{12} + [+v^2b^{21}x^{12} + v^2b^{21}a^{12}(1-a^{22})^{-1}x^{22}] \\ &+ v^2b^{21}a^{12}(1-a^{22})^{-1}e^{21} \end{aligned} \quad (34)$$

The intuition behind this equation is very simple. The first two terms represent country 1 exports of value added. These exports include country 1 value added that is consumed abroad as final good ($v^1b^{11}x^{12}$) and its value added that is used as intermediates to produce final goods consumed in the destination country ($v^1b^{12}x^{22}$). These two terms also correspond to Johnson and Noguera (2012a) measure of vertical specialization "Value added exports". They obviously form a share of country 1 GDP. This is also the case for the following two terms in the second bracketed expression which respectively represent country 1 intermediate exports of value added that are embodied in country 2 exports of final goods to country 1 ($v^2b^{21}x^{12}$), and country 1 intermediate exports of value added that are embodied in country 2 intermediates exports to country 1 and used in the production of final goods consumed there $v^1b^{12}a^{21}(1-a^{11})^{-1}x^{11}$.

It can be easily shown that country 1 GDP equals its value added absorbed abroad (the first two terms), and its value added absorbed at home, namely the two following terms that are firstly exported and finally return home as imports, plus a last term that represents the share of GDP that is never exported. As we can imagine, the terms in the second bracketed expression are doubly counted in trade data. This is so because they are firstly exported by country 1 and exported back by country 2. They therefore appear in the two country exports, and the double counting clearly come from country 2 since they form a share of country 1 GDP. The fifth term is also a doubly counted term ($v^1b^{12}a^{21}(1-a^{11})^{-1}e^{12}$).

According to Koopman et al. (2014), it is doubly counted twice unlike the previous. Intuitively, it represents country 1 value added exports of intermediates to country 2 exported back by this country as intermediates that are used to produce country 1 exports. (They are therefore reembodied in this country exports). If we refer to the GDP breakdown presented above, this value does not appear in any of these countries' GDP_s. Since it appears in both countries exports as the intuition suggests, this explains why it is doubly counted twice. However, as it initially originates from country 1, it necessarily forms a share of its domestic content of exports, that is to say all the value added not initially produced abroad in its exports.

This is thus another measure of vertical specialization different from Johnson and Noguera (2012a) "Value added exports" and which is composed of the first five terms of equation (34). Using the same logic, we can label the last three terms "foreign content in country 1 exports". Respectively, the sixth term and the seventh term represent the foreign value added in its exports of final goods and the foreign value added in its exports of intermediates goods that are finally consumed abroad. They represent equation (34) third and fourth term in country 2 gross exports breakdown. Finally, the eighth term share similar characteristics with the fifth term. They are both doubly counted twice in exports data. Precisely the eighth term in country 1 gross exports breakdown is the counterpart of the fifth term in country 2 exports breakdown and inversely.

With this formula, we can achieve a 100 % breakdown of exports. It is however worthy to note that the expression is slightly different when we are not in a two-country case. In a multi-country case with S countries and 1 sector, we have the following expression:

$$\begin{aligned}E^{i*} = [V^i \sum_{j\neq i}^{S} B^{ii}X^{ij} + V^i \sum_{j\neq i}^{S} B^{ij}X^{jj} + V^i \sum_{s\neq i,j}^{S} \sum_{j\neq i}^{S} B^{is}X^{sj} \ ] + [V^i \sum_{j\neq i}^{S} B^{ij}X^{ji} + \\ V^i \sum_{j\neq i}^{S} B^{ij}A^{ji}(I - A^{ii})^{-1}X^{ii}] + \ V^i \sum_{j\neq i}^{S} B^{ij}A^{ji}(I - A^{ii})^{-1}E^{i*} + \\ [\sum_{s\neq i}^{S} \sum_{j\neq i}^{S} V^s B^{si}X^{ij} \ + \sum_{s\neq i}^{S} \sum_{j\neq i}^{S} V^s B^{si}A^{ij}(I - A^{jj})^{-1}X^{jj}] + \\ \sum_{s\neq i}^{S} V^s B^{si}A^{ij} \ \sum_{j\neq i}^{S} (I - A^{jj})^{-1}E^{j*}]\end{aligned} \tag{35}$$

With E^{i*} a S*1 vector of exports, B a S*S matrix that contains the total requirement coefficients mentioned earlier with B^{ij} as element, X a S*S matrix that contains the final goods produced in exporting countries and consumed in importing countries by sectors with X^{ij}as element, A a S*S matrix of technical coefficients with A^{ij} as element and V^i a 1*S row vector of value-added to gross output ratios. As we can see, the new expression is composed of nine terms rather than eight in the previous one. This is so because country i exported value added is not composed anymore of its value added that is consumed abroad as final good ($V^i \sum_{j\neq i}^{S} B^{ii}X^{ij}$) and its value added that is used as intermediates to produce final goods consumed in the destination countries ($V^i \sum_{j\neq i}^{S} B^{ij}X^{jj}$) only, but also by its value added that is exported to third countries and embodied in their exports of final goods to the rest of the world ($V^i \sum_{s\neq i,j}^{S} \sum_{j\neq i}^{S} B^{is}X^{sj}$).

The other terms have similar interpretations as in equation (34). The fourth and fifth terms represent respectively the value added exported by country i and which is exported back to i by all its trading partners either embodied in final goods consumed there ($V^i \sum_{j\neq i}^{S} B^{ij}X^{ji}$), or as intermediates that are used to produce goods finally consumed there $V^i \sum_{j\neq i}^{S} B^{ij}A^{ji}(I - A^{ii})^{-1}X^{ii}$. They therefore have similar characteristics as the third and fourth term in the previous equation. This is also true for the sixth term which appears in many countries exports without being part of their GDP as the fifth term in the previous equation. The last three terms of this breakdown also represent the foreign content of country r exports, with the ninth term sharing the characteristics of the eight term in equation (34), and the seventh and eighth terms respectively representing the value added imported from abroad and exported back either embodied in final goods, or as intermediate goods.

Bilateral value-added exports directly follow from the first bracketed expression in equation (35). We have:

$$V^{ij} = V^i B^{ii} X^{ij} + V^i B^{ij} X^{jj} + V^i \sum_{s \neq i,j}^{S} B^{is} X^{sj} \tag{36}$$

$\Longrightarrow V^{ij} = \sum_{s=i}^{S} V^i B^{is} X^{sj}$

$\Longrightarrow V^{ij} = \sum_{s=i}^{S} \pi^{is} X^{sj}$

With this framework set, we now turn to the presentation of the GTAP 9 database upon which is based our analysis.

6.C.2 The GTAP database 9

GTAP database 9 is a multi-country input-output matrix composed of 140 regions and 57 sectors that we aggregate into one to perform our analysis. It has 3 reference years notably 2004, 2007 and 2011, among which we choose 2011 to carry out our calculations. The database has 40 arrays that represent different variables. The following are required for our analysis:

TVOM: Sales of domestic products at market prices;

VIMS: Imports at market prices;

VXMD: Non margin exports at market prices;

VST: margin exports;

VTWR: margins by margin commodity;

VIFM: import purchases by firms at market prices;

VIPM: import purchases by households at market prices;

VIGM: import purchases by governments at market prices;

VDFM: domestic purchases by firms at market prices;

VDPM: domestic purchases by households at market prices;

VDGM: domestic purchases by government at market prices;

MFAREV: export tax equivalent of MFA quota premia;

XTREV: ordinary export tax;

TARIFREV: ordinary import duty;

It is worth to note that VDFM and VIFM are composed of firms' purchases of intermediate goods that we denote respectively by $\mathrm{VDFM^I}$ and $\mathrm{VIFM^I}$, and purchases of capital goods that we denote respectively by $\mathrm{VDFM^{CGDS}}$ and $\mathrm{VIFM^{CGDS}}$. The following identities hold between the variables:

$$\sum_{i \neq j} VIMS_{ij} = VIFM_j^I + VIPM_j + VIGM_j + VIFM_j^{CGDS} \tag{37}$$

Which means that a given country total imports of goods are either used for final consumption $VIPM_j + VIGM_j$, investment $VIFM_j^{CGDS}$or intermediate consumption $VIFM_j^I$.

The second identity is also related to the total imports of goods at market prices.

$$\sum_{i \neq j} VIMS_{ij} = \sum_{i \neq j} VXMD_{ij} + XTREV_{ij} + MFAREV_{ij} + TARIFREV_{ij} + VTWR_{ij} \tag{38}$$

It means that imports at market prices embed transportation margins $VTWR_{ij}$ and trade duties that are either export duties $XTREV_{ij} + MFAREV_{ij}$ or import duties $TARIFREV_{ij}$.

The third identity represents the column equilibrium condition of the input output matrix.

$$\begin{aligned} TVOM_j = VDFM_j^I + VIFM_j^I + VDPM_j + VDGM_j + VIGM_j + VIPM_j + \\ VDFM_j^{CGDS} + VIFM_j^{CGDS} + VST_j + \sum_{i \neq j} VXMD_{ji} - VIMS_{ij} \end{aligned} \tag{39}$$

Where the GDP at market prices of country j is represented by $VDPM_j + VDGM_j + VIGM_j + VIPM_j + VDFM_j^{CGDS} + VIFM_j^{CGDS} + \sum_i VXMD_{ji} - VIMS_{ij} + VST_j$ and $VDFM_j^I + VIFM_j^I$ is it's consumption of domestic and intermediate inputs including custom duties and transport margins. The row equilibrium is as following:

$$TVOM_i = VDFM_i^I + VDPM_i + VDGM_i + VDFM_i^{CGDS} + VST_i + \sum_j VXMD_{ij} \tag{40}$$

The following table presents a simplified view of the GTAP database structure. We can see that the database does not give information regarding the end use of exports $VXMD_{AM}$, or regarding the different source countries of intermediate goods imports $VIFM_A^I$.

Table 7: A simplified view of the GTAP data base structure.

	Intermediate use		Final Demand		Rest of world (M)	Gross,output
	Country A	Rest of world (M)	Country A	Rest of world (M)		
Country A	$VDFM_A^I$		$VDPM_A$ $+VDGM_A$ $+VDFM_A^{CGDS}$		$VXMD_{AM}+VST_A$	$TVOM_A$
Rest of World (M)	$VIFM_A^I$					
Value-added	$VDPM_A+VDGM_A$ $+VIGM_A+VIPM_A$ $+VDFM_A^{CGDS}$ $+VIFM_A^{CGDS}+VST_A$ $+VXMD_{AM}-VIMS_{MA}$					
Gross output	$TVOM_A$					

As we saw e, we need a complete set of bilateral intermediate goods exports and final goods exports to obtain our data on value-added exports. To solve this problem, we either use a proportionality assumption or a reconciliation technique that relies on the UN BEC classification of goods by end use categories and detailed trade data at the 6 digits level from UN COMTRADE database.

6.C.3 Disentangling of trade flows by end use

a. The proportionality assumption

Applying the proportionality assumption amounts to assume that the imports of intermediate and final goods of a given country from a particular source are proportional to its total imports from this source. More specifically, we apply this assumption by firstly determining the share $S_{intj}$of intermediate goods in the total amount of goods imported by a given country using the following formula:

$$\frac{VIFM_j^I}{VIMS_j} = S_{intj} \tag{41}$$

Then, we apply this share to bilateral exports from other countries to this given country $VXMD_{ij}$ so as to get bilateral exports of intermediate goods that we label $VXMD_{ij}^I$.

$$VXMD_{ij}^I = S_{intj} * VXMD_{ij} \tag{42}$$

Bilateral exports of final goods $VXMD_{ij}^F$. are then obtained by calculating the difference between bilateral exports of intermediate goods and total bilateral exports.

$$VXMD_{ij}^F = \ VXMD_{ij} - VXMD_{ij}^I \tag{43}$$

These bilateral exports of intermediate goods are net of custom duties and transportation margins. We apply the same share of intermediate goods as before S_{int} to the total amount of custom duties so as to determine the amount that is related to intermediate goods. As regards transportation margins, we determine the bilateral supply of transport services by firstly calculating the share S_{VSTi} of each country in the world total supply of transport services (VST), then, we apply these shares to the total demand of transport services for each country $VTWR_j$ in order to get our variable of interest. Finally, we use the share of intermediate goods S_{intj} to obtain the bilateral supply of transport services regarding intermediate goods. When properly done, the following identities should hold:

$$VIFM_j^I = \sum_i VXMD_{ij}^I + S_{intj} * [(XTREV_{ij} + MFAREV_{ij} + TARIFREV_{ij}) + S_{VSTi} * (VTWR_j)] \tag{44}$$

$$\sum_i VXMD_{ij}^F + (1 - S_{intj}) * [(XTREV_{ij} + MFAREV_{ij} + TARIFREV_{ij}) + S_{VSTi} * (VTWR_j)] = VIPM_j + VIGM_j + VIFM_j^{CGDS} \tag{45}$$

A simplified view of the resulting inter country input output matrix for a two-country case is presented in table 8. Although using the proportionality assumption allows us to disentangle bilateral gross exports into intermediate and final goods exports. It should be noted that this assumption is too restrictive. Some countries are located in the downstream of the production process while other are upstream, which means that the former export relatively more final goods than the latter. The proportionality assumption does not allow us to capture this phenomenon. It could therefore be interesting to obtain the share of intermediate and final goods in each country bilateral exports by relying upon existing classifications of goods by end use.

Table 8: A simplified view of the inter country input output matrix

	Intermediate use		Final Demand		Gross output
	Country A	Country B	Country A	Country B	
Country A	$VDFM_A^I$	$VXMD_{AB}^I + [S_{VSTA} * (VTWR_B) * S_{intB}]$	$VDFM_A^{CGDS}$	$VXMD_{AB}^F$ $+ [S_{VSTA} * (VTWR_B) * (1 - S_{intB})]$	$TVOM_A$
Country B	$VXMD_{BA}^I + [S_{VSTB} * (VTWR_A) * S_{intA}]$	$VDFM_B^I$	$VXMD_{BA}^F$ $+ [S_{VSTB} * (VTWR_A) * (1 - S_{intB})]$	$VDFM_B^{CGDS}$	$TVOM_B$
Custom duties and taxes	S_{intA} $* (XTREV_A + MFAREV_A + TARIFREV_A)$	S_{intB} $* (XTREV_B + MFAREV_B + TARIFREV_B)$			
Value-added	$VDPM_A + VDGM_A$ $+ VIGM_A + VIPM_A$ $+ VDFM_A^{CGDS} + VIFM_A^{CGDS}$ $+ VXMD_A - VIMS_A + VST_A$	$VDPM_B + VDGM_B$ $+ VIGM_B + VIPM_B$ $+ VDFM_B^{CGDS} + VIFM_B^{CGDS}$ $+ VXMD_B - VIMS_B + VST_B$			
Gross output	$TVOM_A$	$TVOM_B$			

b. The UN BEC method

Instead of relying upon ad-hoc assumptions, we use the UN BEC classification of products by end-use category along with the UN COMTRADE database which reports bilateral exports and imports of goods between countries at the HS 6 digits level, in order to obtain the share of intermediate and final goods in the exports of a given country to a particular destination. As regards trade in services, we use data from Francois and Pindyuk (2013) that follow the EBOPS 2002 classification. To distinguish goods and services by their end use category, we use tables of correspondence between the UN BEC revision 4 classification and the HS 2002 classification for goods and the UN BEC revision 5 with the EBOPS classification for services.

These tables of correspondence are available on the UN trade statistics website for the HS/BEC correspondence while for the HS/EBOPS correspondence, we rely on a draft document from the same source that propose a correlation table between the UN BEC revision 5 and the EBOPS classification[19]. We use UN BEC revision 5 rather than revision 4 for trade in services because it does a better job than revision 4 at identifying services. In order to relate these trade flows with the GTAP database, we also use tables of correspondence between the HS 2002 classification, the EBOPS 2002 classification and GTAP sectors. The correspondence tables come respectively from the UN and the European commission websites[20].

At the end of this process, we get goods and services identified by their GTAP sector and their end-use category, be it final consumption, intermediate consumption or both. Some goods and services are therefore used both for final or intermediate consumption, and we need to assign to these goods a unique end-use category to carry-out our analysis. To do so, we use the GTAP database as a benchmark. More precisely, we firstly determine the ratio of intermediate imports over total imports by sector in the GTAP database and with our collected data. Then, we use an allocation method that leads to the convergence of the two ratios. Specifically, if for a given sector the ratio that we get with our collected data is superior to the ratio in the GTAP database, we consider that all the flows remaining which do not have a unique end-use are final goods. If the ratio is inferior, the dual-use items are used as a mean of adjustment to converge to the GTAP database ratio.

These dual-use items represent 10% of the database collected from COMTRADE and Francois et al for the year 2011, which is our year of analysis, and 7% for African countries.

[19] We provide this table of correlation in the online appendix

[20] We provide the table of correspondence between GTAP sectors and the EBOPS classification in the online appendix.

Besides, the African ratio of exported intermediates over final goods equal to 6.35 before the allocation, becomes equal to 5.52 after the allocation which means that African final goods exports are relatively higher after the repartition. It is worth to note that the reliability of trade flows reported in the UN COMTRADE database, or in Francois and Pindyuk (2013) is not the same for every country. For instance, imports reported by Ghana from the USA could be significantly different than the exports reported by the USA to Ghana. To ensure that the database that we get be consistent, we need to take this into account. We do so by calculating a reliability index following Tsigas et al. (2012). We use this index as a weight in the objective function of a quadratic optimization problem that will help us obtain a consistent database[21]. The reliability index is obtained as follows:

$$RIX_i = \frac{XA_i}{\sum_j X_{ij}} \text{ where } XA_i = \sum_{j \in A_{ij} \leq 0.25} X_{ij} \text{ and } A_{ij} = \frac{|M_{ji} - X_{ij}|}{X_{ij}} \tag{46}$$

We then solve the following optimization problem:

$$VIFM_j^I = \sum_i \frac{VIMS_{ij}}{VXMD_{ij}} * VXMD_{ij}^I \tag{47}$$

$$VIPM_j + VIGM_j + VIFM_j^{CGDS} = \sum_i \frac{VIMS_{ij}}{VXMD_{ij}} * VXMD_{ij}^F \tag{48}$$

$$VIFM_j^I = \sum_i VXMD_{ij}^I + S_{intj} * [(XTREV_{ij} + MFAREV_{ij} + TARIFREV_{ij}) + S_{VSTi} * (VTWR_j)] \tag{49}$$

$$VXMD_{ij} = VXMD_{ij}^F + VXMD_{ij}^I \tag{50}$$

$$\begin{aligned} TVOM_j = VDFM_j^I + \sum_i \frac{VIMS_{ij}}{VXMD_{ij}} * VXMD_{ij}^I + VDPM_j + VDGM_j + VIGM_j + VIPM_j \\ + VDFM_j^{CGDS} + VIFM_j^{CGDS} + VST_j + \sum_{i \neq j} VXMD_{ji} - VIMS_{ij} \end{aligned} \tag{51}$$

$$TVOM_i = VDFM_i^I + VDPM_i + VDGM_i + VDFM_i^{CGDS} + VST_i + \sum_j VXMD_{ij}^I + \sum_j VXMD_{ij}^F \tag{52}$$

[21]Some countries such as Taiwan or Puerto Rico are included in the GTAP database, but not in the COMTRADE database. For these, we use a proportionality method to obtain the initial share of intermediate and final goods. We attribute a zero level of reliability to the obtained flows so that our objective function gives less weight to these data in the optimization process.

$$MIN \ (OMEGA) = \frac{1}{2}\left\{\sum_i \sum_j \left(\frac{\left(VXMD^I_{ij} - \overline{VXMD^I_{ij}}\right)^2}{RIX_i{}^{-1}}\right) + \sum_i \sum_j \frac{\left(VXMD^F_{ij} - \overline{VXMD^F_{ij}}\right)^2}{RIX_i{}^{-1}}\right\} \tag{53}$$

Where $\overline{VXMD^I_{ij}}$ and $\overline{VXMD^F_{ij}}$ are initial data obtained from the first breakdown of trade flows between intermediate and final goods respectively and $\frac{VIMS_{ij}}{VXMD_{ij}}$ the ratio between imports inclusive of import duties/transport services and imports at their FOB price. $OMEGA$ is a quadratic objective penalty function that gives more weight to data from reliable exporters, and therefore adjusts more data from unreliable exporters. To preview the results, the correlation between initial and optimized intermediate goods flows is equal to 0.87, while it is equal to 0.92 for final goods. As regards African countries, this correlation is equal to 0.87 for intermediate goods flows, and 0.69 for final goods. More detailed results are presented in table 9.

Table 9: Correlation between collected and optimized data (Author's calculations)

Exporter	Name	Correlation intermediate goods	Correlation final goods	Reliability index
ALB	Albania	0,80	0,50	0,57
ARE	United Arab Emirates	0,00	-0,01	0,00
ARG	Argentina	0,98	0,98	0,78
ARM	Armenia	0,70	0,77	0,47
AUS	Australia	0,99	0,87	0,72
AUT	Austria	0,99	0,99	0,72
AZE	Azerbaijan	0,88	0,74	0,69
BEL	Belgium	0,95	0,96	0,39
BEN	Benin	0,57	0,80	0,21
BFA	Burkina Faso	0,95	0,18	0,01
BGD	Bangladesh	0,35	0,97	0,77
BGR	Bulgaria	0,95	0,91	0,55
BHR	Bahrain	0,42	0,44	0,21
BLR	Belarus	0,56	0,61	0,26
BOL	Bolivia	0,72	0,21	0,55
BRA	Brazil	0,98	0,96	0,67
BRN	Brunei Darussalam	0,96	0,03	0,83
BWA	Botswana	0,99	0,02	0,75
CAN	Canada	1,00	1,00	0,81
CHE	Switzerland	0,94	0,79	0,60
CHL	Chile	0,98	0,86	0,63
CHN	China	0,80	0,88	0,45
CIV	Côte d'Ivoire	0,85	0,69	0,44
CMR	Cameroon	0,63	0,74	0,39
COL	Colombia	0,99	0,80	0,66
CRI	Costa Rica	0,95	0,97	0,59
CYP	Cyprus	0,87	0,89	0,44
CZE	Czech Republic	0,99	0,98	0,50
DEU	Germany	0,98	0,99	0,77
DNK	Denmark	0,95	0,97	0,61
DOM	Dominican Republic P	0,89	0,93	0,46
ECU	Ecuador	0,99	0,72	0,73
EGY	Egypt	0,85	0,85	0,46
ESP	Spain	0,95	0,96	0,69
EST	Estonia	0,93	0,93	0,34
ETH	Ethiopia	0,85	0,83	0,49
FIN	Finland	0,96	0,94	0,65

Table 9 – continued from previous page

Exporter	Name	Correlation intermediate goods	Correlation final goods	Reliability index
FRA	France	0,98	0,99	0,74
GBR	United Kingdom	0,96	0,97	0,63
GEO	Georgia	0,72	0,43	0,39
GHA	Ghana	0,34	0,50	0,14
GIN	Guinea	0,45	-0,02	0,00
GRC	Greece	0,72	0,80	0,64
GTM	Guatemala	0,97	0,90	0,50
HKG	Hong Kong	0,85	0,13	0,02
HND	Honduras	0,88	0,96	0,61
HRV	Croatia	0,88	0,82	0,61
HUN	Hungary	0,99	0,98	0,69
IDN	Indonesia	0,96	0,94	0,66
IND	India	0,88	0,91	0,51
IRL	Ireland	0,95	0,94	0,50
IRN	Iran	0,79	0,47	0,24
ISR	Israel	0,93	0,94	0,57
ITA	Italy	0,99	0,98	0,71
JAM	Jamaica	0,95	0,07	0,45
JOR	Jordan	0,54	0,57	0,33
JPN	Japan	0,95	0,98	0,73
KAZ	Kazakhstan	0,91	0,60	0,30
KEN	Kenya	0,09	0,34	0,00
KGZ	Kyrgyztan	0,94	0,90	0,20
KHM	Cambodia	0,04	0,86	0,44
KOR	Korea, Republic of	0,97	0,98	0,62
KWT	Kuwait	0,66	0,09	0,28
LAO	Lao PDR	0,79	0,22	0,10
LKA	Sri Lanka	0,76	0,75	0,64
LTU	Lithuania	0,82	0,89	0,37
LUX	Luxembourg	0,88	0,75	0,47
LVA	Latvia	0,90	0,90	0,43
MAR	Morocco	0,88	0,78	0,52
MDG	Madagascar	0,71	0,18	0,37
MEX	Mexico	1,00	1,00	0,86
MLT	Malta	0,59	0,64	0,53
MNG	Mongolia	0,30	-0,01	0,00
MOZ	Mozambique	0,34	0,39	0,20
MUS	Mauritius	0,65	0,63	0,54
MWI	Malawi	0,82	0,22	0,17

Table 9 – continued from previous page

Exporter	Name	Correlation intermediate goods	Correlation final goods	Reliability index
MYS	Malaysia	0,94	0,92	0,56
NAM	Namibia	0,70	0,49	0,44
NGA	Nigeria	0,88	0,23	0,26
NIC	Nicaragua	0,87	0,49	0,75
NLD	Netherlands	0,99	0,99	0,54
NOR	Norway	0,85	0,90	0,40
NPL	Nepal	0,01	0,93	0,24
NZL	New Zealand	0,94	0,96	0,75
OMN	Oman	0,98	0,63	0,68
PAK	Pakistan	0,77	0,96	0,60
PAN	Panama	0,95	0,57	0,07
PER	Peru	0,96	0,23	0,50
PHL	Philippines	0,87	0,81	0,26
POL	Poland	0,99	0,98	0,64
PRI	Puerto Rico	0,03	0,00	0,00
PRT	Portugal	0,96	0,97	0,67
PRY	Paraguay	0,85	0,35	0,38
QAT	Qatar	0,95	0,54	0,25
ROU	Romania	0,98	0,97	0,66
RUS	Russia	0,79	0,77	0,35
RWA	Rwanda	0,37	-0,02	0,06
SAU	Saudi Arabia	0,54	0,78	0,41
SEN	Senegal	0,61	0,16	0,24
SGP	Singapore	0,91	0,87	0,26
SLV	El Salvador	0,78	0,98	0,73
SVK	Slovakia	0,97	0,96	0,54
SVN	Slovenia	0,97	0,89	0,59
SWE	Sweden	0,97	0,98	0,69
TGO	Togo	0,35	0,25	0,24
THA	Thailand	0,93	0,96	0,64
TTO	Trinidad and Tobago P	0,99	0,43	0,42
TUN	Tunisia	0,95	0,97	0,61
TUR	Turkey	0,93	0,98	0,59
TWN	Taiwan	0,11	0,34	0,00
TZA	Tanzania	0,75	0,72	0,10
UGA	Uganda	0,47	0,08	0,20
UKR	Ukraine	0,95	0,99	0,72
URY	Uruguay	0,83	0,91	0,71
USA	United States of America	0,96	0,96	0,65

Table 9 – continued from previous page

Exporter	Name	Correlation intermediate goods	Correlation final goods	Reliability index
VEN	Venezuela	0,54	0,31	0,31
VNM	Viet Nam	0,95	0,98	0,63
XAC	South Central Africa	0,99	-0,02	0,93
XCA	Rest of Central America	0,82	0,04	0,84
XCB	Rest of Caribbean	0,89	-0,01	0,14
XCF	Rest of Central Africa	0,78	0,00	0,02
XEA	Rest of East Asia	0,61	0,19	0,07
XEC	Rest of Eastern Africa	-0,01	0,03	0,28
XEE	Rest of Eastern Europe	0,72	0,93	0,38
XEF	Rest of European Free Trade Association	0,68	0,70	0,50
XER	Rest of Europe	0,73	0,66	0,63
XNA	Rest of North America	0,11	0,84	0,90
XNF	Rest of North Africa	0,87	0,05	0,73
XOC	Rest of Oceania	0,91	0,13	0,71
XSA	Rest of South Asia	0,01	0,63	0,10
XSC	Rest of South African Customs Union	0,06	-0,04	0,41
XSE	Rest of Southeast Asia	0,96	0,80	0,47
XSM	Rest of South America	0,78	0,29	0,28
XSU	Rest of Former Soviet Union	0,19	-0,02	0,00
XWF	Rest of Western Africa	0,31	0,17	0,05
XWS	Rest of Western Asia	0,61	0,30	0,24
ZAF	South Africa	0,93	0,79	0,60
ZMB	Zambia	0,94	0,04	0,03
ZWE	Zimbabwe	0,62	0,11	0,03

Table 9 – continued from previous page

Exporter	**Name**	**Correlation intermediate goods**	**Correlation final goods**	**Reliability index**
TOT	TOTAL	0,87	0,92	