In Gravity no *Veritas*: Dubious Trade Elasticity and Weak Effects of Regional Trade Agreements in Africa

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July 8, 2021

Abstract

This article puts into question the use of the gravity equation to analyze Regional Trade Agreements (RTAs) in Africa. By surveying the field qualitatively and quantitatively (via a meta-analysis) and by leading our own estimations (with bilateral fixed effects, exporter-time and importer-time effects) on different trade flow databases (UN COMTRADE, DOTS and BACI), we find that the RTAs elasticity of trade in Africa are unreliable due to their unrealistic high level. By introducing intranational trade and bilateral trends into the regression specification, we show that the coefficient of RTAs in Africa are either not significant or drastically reduced. Only COMESA is still significant. We then use a simple general equilibrium model to compare the results obtained with these new elasticities regarding the terms of trade and welfare for members of the COMESA. We find strong trade

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§We are particularly grateful to Jaime de Melo, José de Sousa, Emmanuelle Lavallée, Carl Gaigné, Souleymane Coulibaly, Lionel Fontagné, Bao Nguyen, Thomas Zylkin and Will Martin, as well as participants of seminars at CATT and at the U.S. International Trade Commission for comments, advices and discussions concerning RTAs in Africa.

creation effects that are largely compensated by trade diversion. The welfare gain of COMESA is for most members very low (less than 0.2% of growth).

1 Introduction

For more than forty years, African countries have enforced many different Regional Trade Agreements (RTAs) that differ in their degree of integration, going from free trade areas to customs and monetary unions, with the ultimate goal to promote trade and growth. What have been the effects of these agreements on trade?

In the meta-analysis on RTAs undertaken by Cipollina and Salvatici (2010) and by Head and Mayer (2014), it is striking to observe that the bulk of the literature has been interested mainly in the EU, NAFTA, MERCOSUR or by RTAs in general, but not by RTAs in Africa.[1] Starting from the fact that trade between African countries only represents small part of their exchange with the world[2] and has apparently not fostered any significant growth, the conventional wisdom has been that many of the RTAs enforced were inefficient. Foroutan (1992) well summarized this consensus for African RTAs enforced before the 90s by noticing that "Regional integration in SSA has fundamentally failed to achieve its goals". However this early literature does not to control for the long list of individual and bilateral variables that can explain the weak continental integration (specialization patterns, regional or civil conflicts, preferential agreements with developed countries, etc). A recent wave of research has started to estimate RTAs in Africa with adequate controls and has found ambiguous results. Mayer and Thoenig (2016) find that members of Regional Economic Community (RECs) have experienced an increase in bilateral trade of 213 percent after the signature the EAC, of 80 percent thanks to the COMESA and of 110 percent via the SADC. Cissokho

[1] Focusing on African trade, the review of De Melo and Tsikata (2015) and Hoekman and Njinkeu (2017) document the lack of analysis of RTAs in Africa.

[2] Around 15% while internal trade between North American countries represents almost 50 percent of their total trade. Similar numbers can be found for Asia, while internal trade in 'fortress Europe' with 27 countries reaches 70 percent. Finally intra-trade between South American countries is around 30 percent.

et al. (2013) also find that agricultural trade within ECOWAS has been very high. Nguyen (2019) observes that the WAEMU has increased the intra-bloc trade by more than 80%. However inside each of these studies, depending of the estimators used and of the control introduced, unsignificant effects are also observed. By leading a meta-analysis on 470 estimates of RTAs in Africa, we find that the estimates of RTAs in Africa vary between 0.5 and 0.8. These values are similar to well-functioning RTAs such as the NAFTA or the EU and appears dubious regarding surveys on firms and reports by international institutions that document the incomplete enforcement of many RTAs in Africa (UNECA, 2010, ITC, 2017).

We investigate whether these results are influenced by the database choice and by the estimator used. Finally we introduce much more control than the literature to take into account omitted variables such as importer-time and exporter-time effects, bilateral fixed effects, bilateral time varying determinants, and a time trend with intranational flows. With these successive introductions, almost all the RTAs in Africa become unsignificant, namely CEMAC, EAC, WAEMU and SADC. In particular, by taking into account internal flows and thus the potential diversion of domestic trade that RTAs involves, and by introducing a time-trend to our bilateral fixed effects in order to better control for bilateral relationship, we find that only COMESA is significant. Moreover this agreement which, in a baseline estimation, is considered to have increased bilateral trade by 122%, has only a trade creation effect of 23% in this specification.

We then analyze how change in this coefficient affects the general equilibrium effect of this agreement. By using a simple New Trade Quantitative Model (NTQM) *à la* Arkolakis et al. (2012), we find that whatever the trade elasticity, COMESA has created trade in the area, but has also generated a substantial level of trade diversion reducing the gains of the regional integration. Overall, the effect of COMESA on real income is weak, around 0.2% of growth for most country in the most favorable scenario.

The remainder of the paper is organized as follows. In Section 2, a brief history of the RTAs in Africa is presented as well as applied tariffs by sectors before the implementation of these agreements. We show that tariffs were relatively low (around or below 10% in most sectors) before the enforcement of RTAs which implies that at least concerning tariffs, no great expectations about a strong reduction due to RTAs was possible. In Section 3, we present our meta-analysis of RTAs in Africa. In Section 4, we run our own estimation using different databases and estimators. In Section 5, we show that the over-estimations of RTAs are reduced once bilateral time-varying control are introduced. The result of the NQTM with the different elasticity of trade of COMESA are presented and discussed in Section 6. Section 7 concludes on the implication of the current research for the future African Continental Free Trade Area (AfCFTA).

2 Gravity with *Gravitas* in Africa, a Review

2.1 Three waves of trade integration

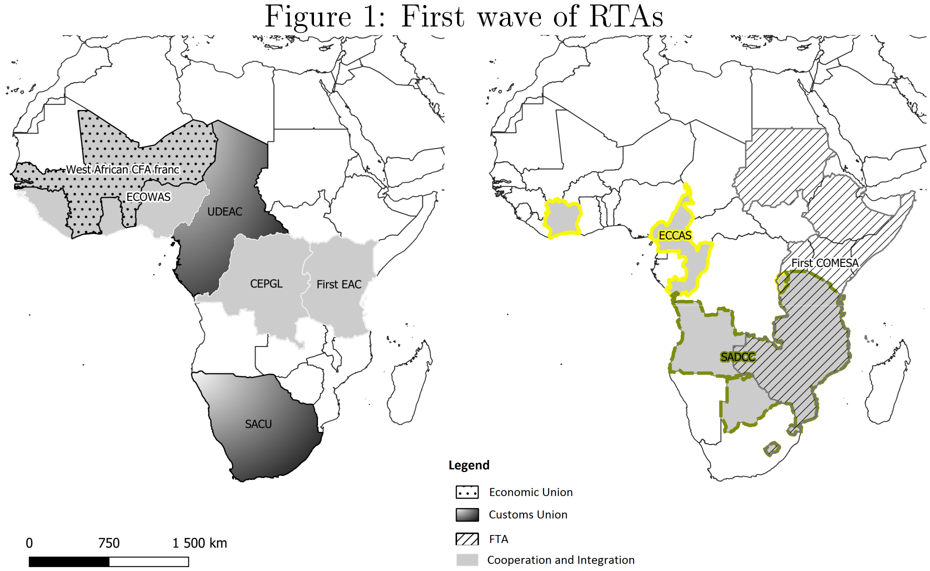
The regional trade integration between African countries has been a very long process since the independence of these countries that took place in the mid-to-late 1950s to the 1980s. The whole history obviously cannot be described in details here, we thus limit this section to a very short analysis, assuming that the details are well known. The Online Appendix A provides a more detailed descriptions of each agreements. Acronyms are also presented in Appendix A. We propose to decompose the enforcement of RTAs in three different period, or "waves", namely 1960-1989, 1990-2015, and 2015 until now.

The first wave of RTAs started after the independence of African countries and ended in the 1980s.

In West Africa, soon after the independence of countries in this area, a monetary union has been created between former French colonies (West African CFA franc), and various agreements (UDAO, UDEAO, CEAO) have been enforced to foster trade in order to build a common market. In this region, a regional intergovernmental organization, ECOWAS, has been launched in 1975 to foster cooperation and trade between francophone and English-speaking countries. In the East, a short-lived EAC (1967-77) has been signed between Kenyan Tanzania and Uganda. In the south, the continent's oldest customs union (created in 1910), the SACU, has been maintained. In Central

Africa, UDEAC and CEPGL have been signed with the objective of moving towards a customs union in the future. Map (2.1, left panel) presents the geographical distribution of these RTAs enforced between 1945 and 1976, and also reveals countries left without agreements (e.g. in North-East or in the immediate North of SACU). But in the 1980s, the spread of RTAs continued to extend to almost the entire continent. In 1981, the largest initiative of a Free Trade Area in Africa, COMESA, has been launched. SADCC[3] has been a step toward a larger integration than SACU in the South. Map (2.1, right panel) presents this second part of the first period of RTAs enforcement, like a puzzle, the two maps are complementary (from a geographical point of view), illustrating that at the end on this first wave (the last entry in COMESA is in 1986), almost all African have signed a regional trade agreements.

Figure 1: First wave of RTAs

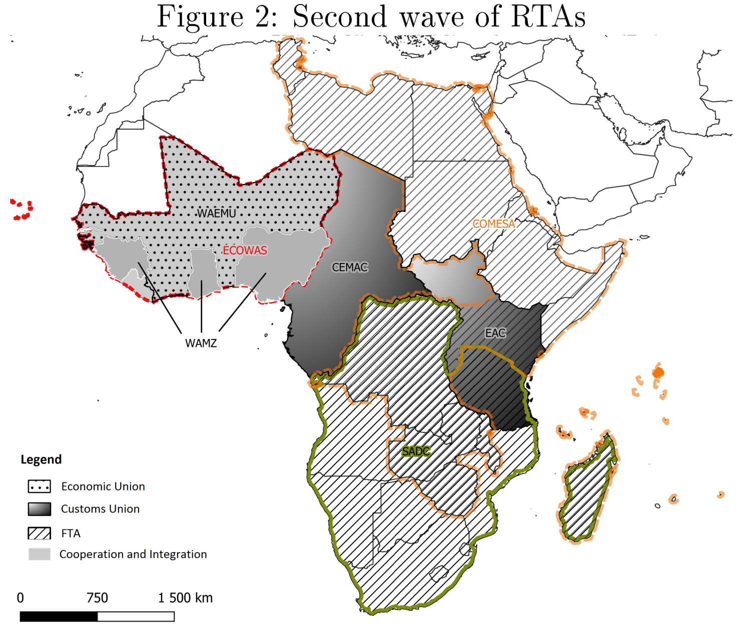


Notes: Members of each agreements has been found on the different institutional websites of the current RTAs and by using the Mario Larch's Regional Trade Agreements Database (Egger and Larch, 2008). The shapefile of African countries comes from the Natural Earth's website.

[3]SADCC was a memorandum of understanding on common economic development, also called the *Lusaka Declaration,* ratified by Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, Zimbabwe (see https://www.sadc.int/about-sadc/overview/history-and-treaty/).

The second wave of regional trade integration span from 1990 to 2015. During that period, the integration network has been improved and became deeper than during the previous one. In the West, members of the CFA franc bloc signed the WAEMU in 1993 which established a FTA and then a customs union in 2000. In the neighborhood, a free trade area, WAMZ, has been signed to advance toward a currency union, which eventually may be adopted by countries of the WAEMU. ECOWAS that regroups members of these two blocs became a customs union in 1995. In Central Africa, UDEAC gave way to CEMAC, a customs union enforced in 1999. In the East, a new EAC has been enforced in 2000 by Kenya, Tanzania and Uganda and then by Rwanda and Burundi in 2007 and finally by South Sudan in 2016. This bloc became a fully-fledged Customs Union in 2009. In the South, SADC, a new FTA enforced in 1999, succeeded to unite SACU and SADCC. Finally, COMESA became a customs union in 1993. The enlargement of this bloc is also extended and now stretched from Tunisia to Botswana (see Map, 2.1).

Figure 2: Second wave of RTAs



Notes: Members of each agreements has been found on the different institutional websites of the current RTAs and by using the Mario Larch's Regional Trade Agreements Database (Egger and Larch, 2008). The shapefile of African countries comes from the Natural Earth's website.

The last wave has started in 2015 to unite all the African continent. A Tripartite Free Trade Area (TFTA) has been discussed between the Common Market for Eastern and Southern Africa (COMESA), Southern African Development Community (SADC) and East African Community (EAC). On June 15, 2015 at the 25th African Union Summit in Johannesburg, the African Continental Free Trade Area (AfCFTA) is launched aiming to create a FTA between 54 African countries. In 2021, this AfCFTA has still not been signed by all the 54 members.

2.2 Stylized facts about tariffs and integration

To present the achievement of the first wave of RTAs, and the potential of the second wave, we describe in Figure (2.2) the aggregated tariffs between members of CEMAC, EAC, COMESA and SADC before their implementation in the 1990s. Tariffs for other RTAs are not available for all countries and are thus not reported.

Data come from the United Nation Conference on Trade And Development Trade Analysis Information System (UNCTAD-TRAINS). When the data is lacking, we take the tariff set in a recent past year (four years before at the maximum). To aggregate these data, tariffs are weighted by the total imports of each country. The bias of this weighting scheme is well known (Balassa, 1965), this methodology underestimates the protection by artificially lowering the average rate of tariffs (e.g. a high tariff sharply reduces imports, which lowers the weight of the good). We obtain however very similar results by using different weighting scheme (e.g. by exports).

Table 1: RTAs in Africa

	Type	Signature	Entry in force
EAC	FTA	1999	2000*
	CU	2009	2010
COMESA	FTA	1993	1994*
WAEMU	FTA	1993	1994*
	CU	2000	2004
ECOWAS	FTA	1975	1975*
	CU	1993	1995
CEMAC	CU	1994	1999*
SADC	FTA	1996	2000*

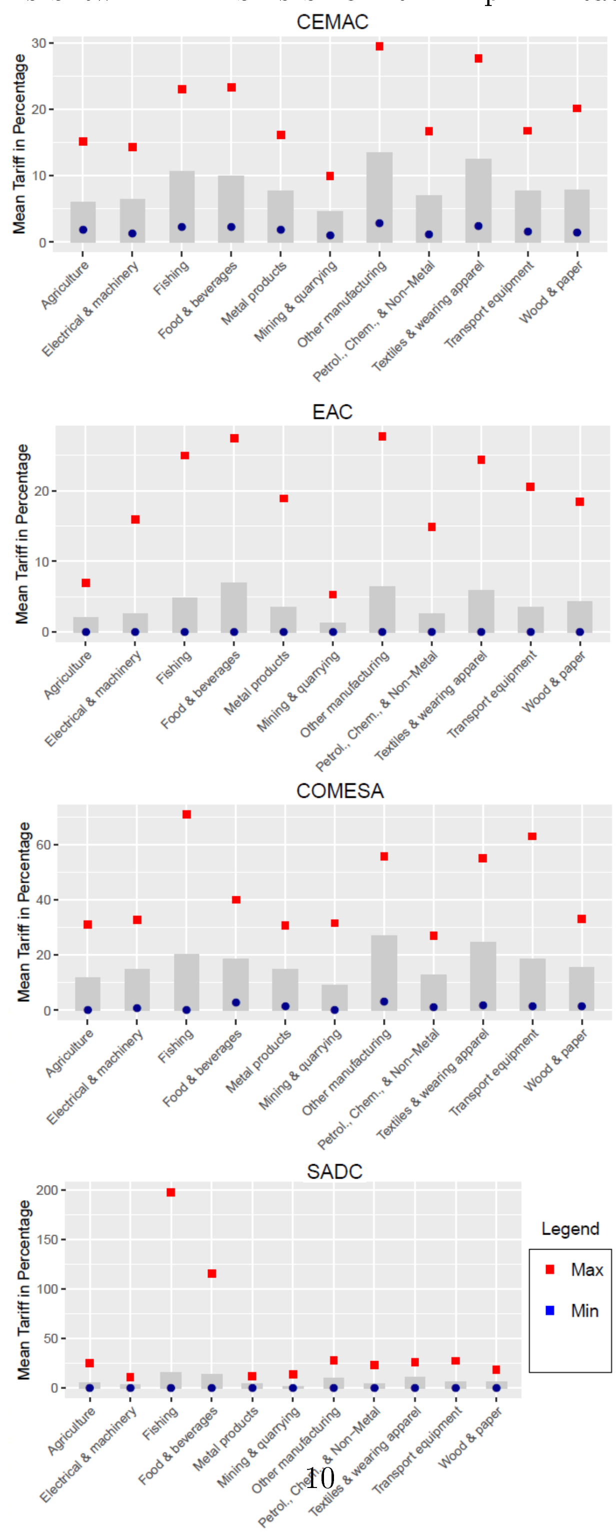
Notes: FTA: Free Trade Agreement, CU: Custom Union, CM: Common Market. "*" represents the starting dates that are taken into account to build our dummies of African's RTAs.

As illustrated in Figure (2.2), before the implementation of CEMAC, the future members imposed tariff barriers to their regional partners between 5% and 15%. While some members imposed higher tariffs often exceeding 20% in Foods, Fishing and Manufacturing goods, the average level of tariffs is low, indicating that the potential gains of a reduction of them are limited. In the East, tariffs before the EAC were even smaller, around 5% in many sectors. In the South, tariff rates between members of the SADC were also already relatively small before 1995, with however a significant heterogeneity in specific sectors with tariff peaks in Fishing, Food and Beverages. Before the deeper integration of the COMESA in 1993, goods in this bloc were taxed around 10% (Fishing, Foods & Beverages, Manufactures, Textiles & Wearing Apparel), but in some countries the tariff rate reached 60% (see Figure 2.2).

To sum up, the first wave of RTAs has succeeded to reduce tariffs barriers between member of COMESA, EAC, SADC and CEMAC. Thus the potential impact of the second wave concerning tariffs seems weak but with some potential effects regarding sensitive products with prohibitive tariffs. However, while in theory tariffs have been reduced, in practice anecdotal evidence shows the disability/unwillingness of some countries to implement the law. For instance, surveys on firms reveal that despite the *de jure* total exemption of customs taxes and duties inside the ECOWAS, firms complain that taxes are applied *de facto* by member countries on imported products (see for instance ITC, 2017). Bensassi et al. (2019) also report that while trade in local unprocessed goods has been liberalized since 1993, these goods were still taxed inside ECOWAS in 2011. Finally, beyond tariffs, many Non-

Tariff Barriers (NTBs) are known to limit trade inside many blocs in Africa (de Melo and Tsikata, 2015).

Figure 3: Tariffs between members before the implementation of the RTA



Notes: *Max* represents the highest tariff set in each sectors by one member of the RTA to its partners in this regional area. *Min* represents the lowest tariff set in each sectors by one member of the RTA to its partners in this regional area. Tariffs at the goods level are weighted by the total imports of each country. *Mean* is the average of tariffs inside the bloc. Tariffs are calculated before the implementation of each RTAs, namely in 1998 for CEMAC, 1999 for EAC and SADC and 1993 for COMESA. When the data is lacking, the tariff set in the past four years is used. Data on tariffs comes from the United Nation Conference on Trade And Development Trade Analysis Information System (UNCTAD-TRAINS).

2.3 A Meta-analysis of the Trade Elasticity of RTAs in Africa

We propose here a meta-analysis of all the gravity equations estimated on RTAs in Africa that we have found by using the "search tool" of a large variety of journal (Journal of International Economics, Journal of Development Economics, World Development, World Bank Economic Review, Journal of African Economies, Journal of Economic Integration, Review of International Economics, The World Economy). We also look for unpublished manuscripts on Google Scholar. We have found 22 published and unpublished articles which gives a database of 423 estimates (see Appendix B for the list).

Studies are very heterogeneous regarding the estimators used, going through Ordinary Least Square (OLS), Fixed-Effect (FE), Poisson Pseudo-Maximum Likelihood (PPML), GMM or TOBIT. In Table (2) we give the general results of this meta-analysis by considering all these estimators. We also propose an analysis based on studies using the OLS, the FE, and the PPML estimators, which are the most frequently used estimators.

To understand how we have classified the different estimates, the description of the following gravity equation may be useful:

$$X_{odt} = \alpha + \beta.y_{ot} + \gamma.y_{dt} + \delta.d_{od} + \lambda.RTA_{odt}^{African} + \epsilon_{odt}, \qquad (1)$$

In studies using the OLS estimator, trade flows X_{odt} are often taken in Logarithm, zero trade flows are dropped (or replaced by 1), time-varying indicators of export capacity or of demand, y_{ot} and y_{dt}, are often approximated by GDPs, time-unvarying bilateral determinants of exports, d_{od}, are approximated by distance (and other dummies such as past colonial links, common language, etc). $RTA_{odt}^{African}$ refers to a vector of dummies taking one the year when an African RTA is enforced.

This estimation, also called the "naive gravity equation" has well-known drawbacks (see Baldwin and Taglioni, 2007). This specification, without control for exporter and importer unvarying factors, provides estimates that are biased towards zero (Head and Mayer, 2014).

We classify in the OLS-FE category (sometimes only called FE), all the studies that used OLS with fixed effects, such as:

$$X_{odt} = \alpha + \beta.y_{ot} + \gamma.y_{dt} + \delta.d_{od} + \lambda.RTA_{odt}^{African} + f_o + f_d + f_t + \epsilon_{odt}, \quad (2)$$

where f_o and f_d are country-fixed effects and f_t a time-effect. This equation is often considered as a structural estimation of the theoretical gravity equation presented in Anderson (1979) and Anderson and van Wincoop (2003). There is however a strong heterogeneity in this estimation of the structural gravity equation. Some authors replace time-varying country-specific variables of Equation (2), such as GDPs (y_{ot} and y_{dt}), by time-varying country-specific effects f_{ot} and f_{dt}. Some studies (very few, mainly Mayer and Thoenig, 2016 and Nguyen, 2019) replaced bilateral variables such as distance by bilateral fixed effects, f_{od}.

Finally the typical equation of articles using the PPML-FE estimator (sometimes only called PPML) takes the following form:

$$X_{odt} = \exp\left[\alpha + \beta.y_{ot} + \gamma.y_{dt} + \delta.d_{od} + \lambda.RTA_{odt}^{African} + f_o + f_d + f_t\right] + \epsilon_{odt}, \quad (3)$$

In these studies, zero trade flows are taken into account. As with the FE model estimated with the OLS estimator, the set of fixed effects varies from one study to another. Only two studies use time-varying country-specific effects f_{ot} and f_{dt} and bilateral fixed effects f_{od} instead of distance and GDPs (Magee, 2008, Nguyen, 2019).

Combining these multiple estimates of λ from different studies raise the issue of heterogeneity within and across studies. To account for this heterogeneity, we adopt the technique of Higgins and Thompson (2002), who calculate a weighted average of the estimates underlying each study, called the "single true effect" of African RTAs, hereafter denoted $\hat{\psi}_F$ and given by:

$$\hat{\psi_F} = \frac{\sum_{i=1}^{n}(\hat{\theta}_i w_i)}{\sum_{i}^{n} w_i}$$

where n is the number of estimations and w_i is equal to inverse square of standard error.

This weighted average effect enables to perform the homogeneity test (Q-test) which is useful to distinguish the Fixed Effect Model (FEM) to the Random Effect Model (REM). When the Q-test is not rejected, the FEM is the most suitable model, the differences between studies are only due to internal variation. When this test is rejected (heterogeneity), the REM is appropriate to take into account intra-study variability and inter-study variability. Without surprise, the homogeneity is rejected, there is a strong heterogeneity within and between the majority of studies, and we thus present in Table (2) the results with the REM (we report in the Online Appendix D the results with the FEM). By considering the whole sample, we find a mean of 0.119 with a confidence interval above, but close to zero (from 0.099 to 0.138), indicating that the effect of RTAs has been low, increasing trade by only 12% ($e^{0.119}$-1). Results by estimators illustrate the heterogeneity obtained.

ECOWAS: a trade creation between 0 and 5360%

According to the meta-analysis and by considering only the PPML-FE strategy, ECOWAS is the RTA with the largest effect fostering regional trade by 107% ($e^{0.729}$-1). This RTAs is also the most performing for studies using the OLS-FE model (0.906), while results with naive specification (OLS without fixed effects) provide a different picture, placing this RTAs in the middle of the distribution of trade creation (0.514). Among the studies concluding that this agreement has fostered trade between members, there are Carrere (2004), Ngepah and Udeagha (2018) and Musila (2005). Cissokho and Seck (2013) even find (using the PPML estimator) that ECOWAS increases trade by over 5360%! However a qualitative analysis of the literature shows that there is no consensus. Using the Generalized Method of Moments (GMM) to address the potential endogeneity of RTAs, Elbadawi (1997) finds that this agreement is not significant. Using the PPML estimator, Magee (2008) shows that once bilateral fixed effects are introduced the trade creation inside this community is no longer significant.

WAEMU: significant ambiguous results

Contrasting results are also found for the WAEMU with a coefficient of trade creation between 0.375 with PPML and 0.99 with OLS (Table, 2). Eicher and Henn (2011) and Glick and Rose (2016) analyzing different common currency zones, find for instance that the CFA Franc zone has stimulated trade more that the euro zone and/or the US dollar zone. More precisely, they get an elasticity of the CFA Franc zone around 0.7 while the trade elasticity of the Economic and Monetary Union in Europe (EMU) is around 0.5. Carrere (2004, 2013) also finds that this REC has created a significant amount of trade between partners. Nguyen (2019) finds a similar results, but once controls for bilateral relationships (using pair-fixed effects) are introduced, this RTA become unsignificant to explain trade.

CEMAC: much ado nothing?

Results concerning the CEMAC differs strongly from one estimator to the other. While a strong effect is found with the OLS estimator, other studies using the FE model, or the PPML estimator find that this agreement has been unsignificant (and in some cases, it is significant and negative). Since studies in OLS neither control for multilateral resistance, nor for heteroskedasticity, this agreement is maybe the only one on which we can reach a firm conclusion: CEMAC has not fostered trade between its members.

Small is beautiful: has the EAC increased regional trade by 121%?

The EAC is the agreement for which results of the meta-analysis converge the most, providing coefficient between 0.164 (FE) and 0.294 (PPML). This however does not mean that all the studies find coefficient in this range. For instance, Mayer and Thoenig (2016) using a gravity equation with country-time and bilateral fixed effects with the FE model, find a coefficient of 0.797.

SADC: boosting regional trade by 100%?

According to many studies the SADC has significantly fostered trade between members (Carrere, 2004; Ngepah and Udeagha, 2018; Subramanian and Tamirisa, 2001; Cernat, 2001; Djoumessi and Bala, 2017; Cissokho et al., 2013). However, depending to the specification used, non significant effects are also observed in Mayer and Thoenig (2016), Nguyen (2019) and in MacPhee et Sattayanuwat (2014). The meta-analysis indicates that studies with the FE model find a coefficient twice higher than with the OLS estimator (0.825 versus 0.424). Articles using the PPML estimator find an intermediate value of 0.693, raising intra-trade by 100%.

Bigger is better: has the COMESA increased regional trade by 71%?

The COMESA is maybe one of the agreement where many contradictory results are found even inside each study. To give one example, Mayer and Thoenig (2016) use a particular approach (the "tetrad strategy" of Head, Mayer and Ries, 2010) and find that the significant effect of COMESA is not robust to simple change in their computation (i.e. their weighting scheme using an average of countries instead of UK and France). The meta-analysis shows that the OLS estimates of λ are six time smaller than the one obtained with the FE model. Once again, estimations with the PPML-FE estimator provide an intermediate value of 0.537 (raising intra-trade by 71%).

Table 2: A meta-analysis of African RTAs

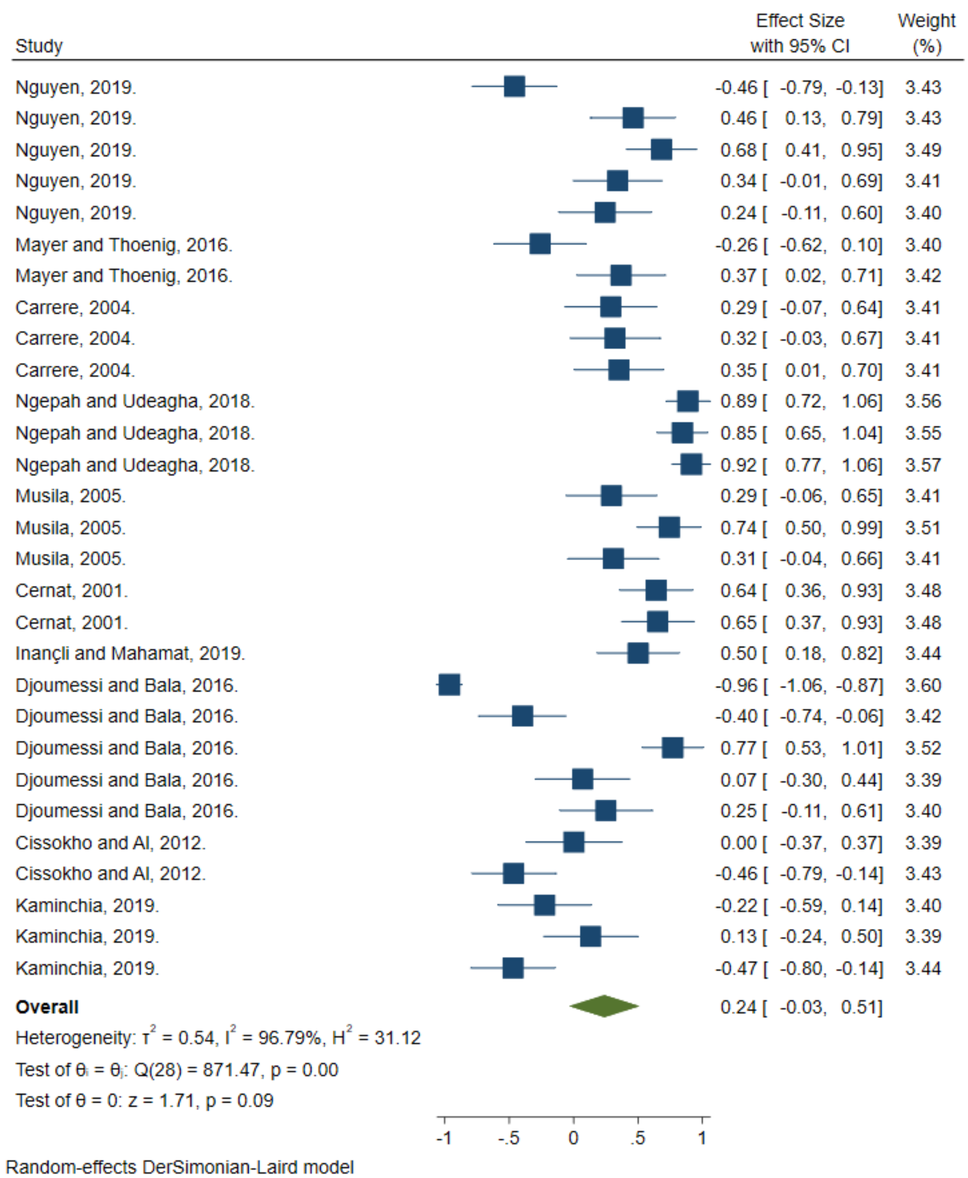
RTAs	Estimators	Effects	P-value	Lower bound of 95% CI	Upper bound of 95% CI	Nb. Estim.
ECOWAS	OLS	0.514	0.000	0.319	0.709	28
	OLS-FE	0.906	0.000	0.757	1.055	6
	PPML-FE	0.729	0.000	0.397	1.061	5
COMESA	OLS	0.195	0.039	0.010	0.381	26
	OLS-FE	0.672	0.001	0.277	1.067	5
	PPML-FE	0.537	0.000	0.261	0.813	10
EAC	OLS	0.165	0.310	-0.153	0.482	16
	OLS-FE	0.164	0.001	0.064	0.264	52
	PPML-FE	0.294	0.009	0.073	0.515	24
CEMAC	OLS	0.881	0.000	0.680	1.082	5
	OLS FE	-0.565	0.056	-1.143	0.013	3
	PPML-FE	-0.134	0.438	-0.471	0.204	13
WAEMU	OLS	0.990	0.000	0.791	1.188	2
	OLS-FE	0.823	0.000	0.698	0.948	9
	PPML-FE	0.375	0.106	-0.079	0.830	13
SADC	OLS	0.424	0.005	0.129	0.718	14
	OLS-FE	0.825	0.000	0.586	1.064	5
	PPML-FE	0.693	0.000	0.493	0.893	12
Overall		0.119	0.000	0.098	0.140	423

Notes: Meta-analysis is done with the Random Effect Model on 423 estimates of RTAs in Africa, obtained from 22 published and unpublished articles.

What to conclude?

By surveying the literature in this section, we have seen that the different studies often present ambiguous results. While some articles obtain strong and significant evidence of trade creation, other present unsignificant results. The forest plot (2.3), done on specification that gives the highest R^2, illustrates this strong heterogeneity, showing estimates for the COMESA that are between -1 and 1 (similar results are obtained for other RTAs).

Figure 4: Forest plot of the COMESA



Notes: The forest plot is done here for the estimates of the trade effect of the COMESA from 29 estimates obtained from 10 articles.

Our current meta-analysis fails to determine which estimator provides systematically the lowest or the highest effect of RTAs on African trade,[4] but leads us to conclude that for ECOWAS, COMESA and SADC, studies using PPML provide coefficients between 0.5 and 0.8. This result is worth comparing with what has been obtained elsewhere in the world. Cipollina and Salvatici (2010) find that the mean coefficient for NAFTA is equal to 0.90 and 0.52 for the EU. From this comparison, the coefficients of RTAs in Africa appears relatively high. As emphasized during our analysis of the history of the African trade regionalization, tariffs were low before the implementation of RTAs and non-tariffs barriers have not been strongly reduced, it is thus surprising to observe that these RTAs have been as efficient as the deep integration fostered by the EU or the NAFTA.

One potential problem of the many research presented in our meta-analysis concerns the lack of control for confounding factors of trade and RTAs. Before 2004, no study introduces country fixed effects (and thus do not control for multilateral resistances, see Anderson and van Wincoop, 2003). After that date, while these fixed effects are more systematically incorporated, very few articles introduce country-pair fixed effects. Thus the endogeneity bias due to omitted factors is still a serious concern. If we consider the state-of-the-art practice (see Head and Mayer, 2014) that recommends to use PPML with importer-year, exporter-year and country-pair fixed effects then only two studies should be considered, namely Guepie and Schlick (2019) and Magee (2008). If we relax this definition by considering estimations with country fixed effects (instead of importer-year, exporter-year) and the FE model, then we can only add Nguyen (2019) and Mayer and Thoenig (2016). From these four studies, it is still hard to reach a consensus since they use different databases, analyze different RTAs and obtain different results. We thus propose to lead our own analysis.

[4]For instance, the weakest coefficient is obtained with OLS for SADC but the reverse hold for WAEMU. This ambiguous result can also be found by comparing the meta-analysis of Head and Mayer (2014) and Cipollina and Salvatici (2010), who by working on different samples, find different results. Head and Mayer (2004) observe that researches using the OLS estimator provide estimates of RTAs that are weaker than estimations of the structural gravity equation (FE), whereas Cipollina and Salvatici (2010) find the opposite.

3 Trade Flows Data and Bilateral Omitted Variables

3.1 Empirical strategy

The contribution to this section is to introduce country-pair fixed effects as recommended by the literature but rarely used to analyze African trade. These bilateral fixed effects imply that the identification comes from the within dimension of the data and reduce the bias of omitted variables. It is possible that the introduction of these additional controls lead to a reduction of the coefficient of RTAs. For instance Glick and Rose (2002) find that the common currency effect is divided by two with these fixed effects. However, there is no certainty, it depends of the unobserved variables that are taken into account. If two countries have a bad political relationship during the whole period, then the coefficient of RTA may be underestimated. Baier and Bergstrand (2007) find that the RTA estimate is twice higher with these controls than without.

We estimate the following equation using the PPML estimator:

$$X_{odt} = \exp\left[\alpha + f_{ot} + f_{dt} + f_{od} + \phi_{odt}\right] + \epsilon_{odt}, \tag{4}$$

and a similar equation (without the exponential) with the FE model, where f_{ot} and f_{dt} are time-varying country-specific effects approximating exporting and importing capacity and f_{od} bilateral fixed effects to control for all unobserved time-unvarying bilateral determinants of exports. The term ϕ_{odt} takes into account African and other RTAs that can explain trade:

$$\phi_{odt} = \psi.RTA^{African}_{odt} + \lambda.RTA^{Other}_{odt}, \tag{5}$$

where $RTA^{African}_{odt}$ refers to a vector of dummies taking one the year when an African RTA is enforced (see Table 1, Column 2)[5]. We consider the six RTAs surveyed until now, namely COMESA, EAC, WAEMU, CEMAC, SADC and ECOWAS. RTA^{Other}_{odt} takes one for all other RTAs (such as the

[5] For ECOWAS, EAC and WAEMU we take the year of the implementation of FTAs (i.e. 1975, 2000, 1994)

European Union, or preferential agreements such as the Generalized System of Preferences). These dummies are computed from Mario Larch's Regional Trade Agreements Database (Egger and Larch, 2008).[6]

Concerning trade flows we use the IMF's DOTS database which is the most widely used in the literature due to its long time period and to some corrections that have brought to the data to take into account slow reporting countries. In the Online Appendix B, we however discuss this choice and compare the results obtained with COMTRADE (from the United Nations) and BACI (from the CEPII) which are the two other databases the most frequently used.[7] We found that DOTS provides the smallest coefficient of RTAs when using the PPML estimator. The time period of our analysis is from 1962 to 2014 and thus takes into account the two first waves of RTAs presented previously. Another advantage to use this long-run panel for trade in goods is related to the fact that RTAs are identified on a few observations inside a country pair and then using a long time period reduces the risk of small sample bias (Limao, 2016).

3.2 Results

In Column 1 and 2 of Table (3), we report the results using successively OLS-FE and PPML-FE. We find that for SADC and ECOWAS, the coefficient of the RTAs dummy is smaller when heteroskedasticity and zero trade flows are taken into account with the PPML-FE strategy.[8] However, this decrease in the coefficient estimated is not always verified, for example the coefficient of COMESA is almost unaffected. Regarding the EAC, we find that this agreement is significant with OLS-FE in Column 1 (as Mayer and Thoenig, 2016), but loses its explanatory power with PPML-FE (Column 2).

Since the first order conditions of the linear-in-logs OLS and PPML-FE estimators are different, the direct comparison may be misleading (see

[6]https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html

[7]Some other database are used, but less frequently. For instance Magee (2008) uses the Statistics Canada's World Trade Analyzer and Candau et al. (2019) use Tradehist, an historical data base on trade flows proposed by the CEPII.

[8]Santos Silva and Tenreyro (2006) find a similar result for concerning preferential trade agreements.

Eaton et al., 2013; Head and Mayer, 2014, Mayer et al., 2019, Martin, 2021). PPML is applied on the deviations from levels of the flow with respect to the prediction, while the OLS is applied on log deviations. Consequently OLS may put less weight on pairs of countries with large levels of trade than PPML. Then to compare more rigorously the two estimators, in Column 3 we apply weights proportional to levels of flows to the linear-in-logs specification (as recommended by Mayer et al. 2019). In Column 4 we estimate again our baseline equation with the PPML-FE model but this time on trade shares (bilateral imports divided by total imports) instead of trade flows (as in Eaton et al. 2013). This specification naturally give less weight to large flows in levels. The OLS-FE with weighted trade flows provides smaller coefficients for the EAC, COMESA and SADC, but higher coefficients for other agreements (Column 3). With the PPML-FE applied on trade shares, EAC and COMESA are not significant, but this estimation provides dubious results for WAEMU and ECOWAS (significant negative effects). In Column 5 we test whether these results are due to the high number of zero in trade shares by leading the same estimation but on positive trade shares only. At the exception of EAC, all the coefficients appears much more smaller (and realistic) with this last estimation.

Table 3: RTAs in Africa

Estimator:	OLS-FE	PPML-FE	OLS-weigh	PPML-share	PPML-share>0
EAC	1.649[a]	0.388	0.480[c]	0.244	0.754[a]
	(0.310)	(0.357)	(0.248)	(0.205)	(0.205)
$COMESA$	0.895[a]	0.848[a]	0.645[a]	0.047	0.373[a]
	(0.110)	(0.175)	(0.123)	(0.106)	(0.103)
$WAEMU$	0.648[a]	0.636[a]	0.803[a]	-0.493[a]	0.239
	(0.238)	(0.199)	(0.171)	(0.176)	(0.172)
$ECOWAS$	0.639[a]	0.579[b]	1.463[a]	-0.254[c]	0.010
	(0.203)	(0.279)	(0.516)	(0.138)	(0.137)
$CEMAC$	-0.218	0.339	0.597[c]	-0.291	-0.046
	(0.407)	(0.336)	(0.319)	(0.278)	(0.274)
$SADC$	1.196[a]	0.867[a]	0.687[a]	0.027	0.396[a]
	(0.172)	(0.146)	(0.143)	(0.143)	(0.142)
RTA^{Other}	0.334[a]	0.025	-0.010	0.038	0.100[a]
	(0.032)	(0.053)	(0.049)	(0.026)	(0.025)
$Constant$	14.271[a]		22.591[a]		
	(0.005)		(0.026)		
OBS	517381	764314	517381	756839	517,832
R^2	0.858	0.990	0.986	0.240	0.246

Notes: [a],[b] denote significance at the 1 and 5 percent level respectively. Robust clustered standard errors are reported under each coefficient. Every estimation has been done with importer-time and exporter-time effects and with country-pair effects (f_{ot} , f_{dt} , f_{od}). In Column 1 and 2, the dependent variable (trade flows) comes from DOTS compilled by IMF. In Column 3, we apply weights proportional to the level of flows. In Column 4 and 5, we analyse trade shares including zero in Column 4 and without in Column 5. The time period is 1962-2014.

4 Why are RTAs in Africa Overestimated?

4.1 Pasts RTAs and bilateral time varying variables

One potential problem of the previous analysis is the lack of control concerning variables that, like RTAs, vary bilaterally and over time. Bilateral fixed effects take into account long time relationship between members but time varying bilateral characteristics explaining trade should also be taken into account.

GATT/WTO membership

The objective of the GATT/WTO has been to foster trade between nations. A seft-provided description of the WTO for instance states that "by lowering trade barriers, the WTO's system also breaks down other barriers between peoples and nations".[9] While there is a vast debate on this topic, the economic literature seems to conclude of that the GATT/WTO membership has succeeded to liberalize trade.[10]

At the time that followed the creation of the GATT, the African continent was divided by the cold war and then by the "non-aligned" movement, hence the adhesion to the GATT and then to the WTO has been progressive, and the diffusion of this adhesion has often taken a regional dimension. As a consequence, it is possible that our variables of RTAs capture the effect of the GATT/WTO membership. Another possibility is that by reducing the cost of international trade relatively to regional trade, the GATT/WTO membership has led to underestimate the effect of RTA. We thus introduce a dummy taking one when the two partners belong the GATT/WTO.

Bilateral Wars

The list of conflicts at the border is unfortunately long in Africa, we have identified 157 bilateral conflicts over the period of our analysis (1962-2010) and still 78 wars between 1990 and 2010. One can enumerate 2 wars inside WAEMU, 4 between countries of the EAC, 4 among members of the CEMAC, 30 conflicts inside ECOWAS and 23 in COMESA. These wars have obviously affected regional trade relatively to the rest-of-the world leading to a potential bias of the coefficient of RTA.

Past RTAs

Another concerns is related to the trade integration timetable of RTAs. At least since Aitken (1973) the lagged effect of trade agreements has been deeply analyzed. For instance, Dür et al. (2014) analyzing 587 trade agreements find that the tariff eliminations procedure of an FTA needs almost 6 years to be implemented. Baier and Bergstrand (2007) even find a longer period of 15 years before to observe the full effect of RTA on trade of members after the

[9] Quotation from Rose (2004).

[10] Rose (2004) finds that members of the GATT/WTO do not trade more than external countries. Tomz et al. (2007) argues that Rose (2004) does not include countries that participated but were not members (e.g. colonies). Through data improvements, they show that GATT/WTO have large effects. See Rose (2007) for a reply and discussion.

signature of the agreements. Regarding African countries, it is also possible that the dummies built to proxy the most recent RTAs of the second wave simply capture RTAs of the first wave. Indeed, as we have briefly exposed in our history of RTAs, many agreements were initiated by the formation of communities many years before the enforcement of the current RTAs. In that case, the lack of control concerning these past agreements, can biased upward the RTAs that we analyze. We thus introduce a dummy of all the agreements implemented during the first wave of regional integration in Africa.

Results with time-varying bilateral variables

We estimate the previous gravity equation (4) but with a new vector of bilateral variables that vary over time:

$$\phi_{odt} = \psi.RTA_{odt}^{African} + \lambda.RTA_{odt}^{Other} + \beta.PastRTA_{odt}^{African} + GATT_{odt} + WAR_{odt}. \quad (6)$$

$RTA_{odt}^{African}$ and RTA_{odt}^{Other} have already been defined previously. $PastRTA_{odt}^{African}$ is a vector of dummies taking one when an ancestor of the current agreements is enforced in the year t (e.g. for all the years between 1967 and 1977 for which the first EAC is implemented, this dummy takes one for members of this agreement, and zero for all the other years of the sample), such as UDAO, UDEAO, CEAO, UDEAC, SADCC or EAC (1967-1977). All these dummies concerning RTAs are computed from Mario Larch's Regional Trade Agreements Database (Egger and Larch, 2008).[11] Data on GATT and WTO membership is taken from the WTO.[12] Bilateral military conflicts come from the Correlates of War (COW) project that makes available a very large array of data sets related to armed conflicts. These data on wars end in 2010, thus estimations with them concern the period 1962-2010.

To differentiate the effect of past RTAs to the introduction of military conflicts, we estimate the gravity equation by introducing these variables sequentially. The regression is done on DOTS (but see the Online Appendix C for results based on COMTRADE and BACI) with the PPML estimator. Column 1 of Table (4) is the baseline presented in the previous section (Col-

[11] https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html

[12] https://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm

umn 2 of Table 3), Column 2 introduces past RTAs and Column 3 adds the WTO membership and the dummy on wars. In most cases, the addition of past RTAs (Column 2) and of bilateral time varying variables (Column 3) leads to reduce the coefficient of RTAs. This is the case for EAC, COMESA, WAEMU and CEMAC. While coefficient of the EAC and the CEMAC are never significant, the introduction of these variables in Column 2 and 3 lead to reject the hypothesis that λ is significantly different to zero for WAEMU. Beside these four agreements, coefficients of ECOWAS and SADC are inflated by the introduction of past RTAs, WTO and wars which shows that some problems remain.

Table 4: RTAs in Africa

Control	Baseline	+ Past RTAs	+ WTO + Wars
EAC	0.388	0.337	0.284
	(0.357)	(0.342)	(0.360)
$COMESA$	0.848^a	0.674^a	0.633^a
	(0.175)	(0.258)	(0.244)
$WAEMU$	0.636^a	0.149	0.103
	(0.199)	(0.276)	(0.259)
$ECOWAS$	0.579^b	0.907^a	1.052^a
	(0.279)	(0.295)	(0.305)
$CEMAC$	0.339	0.076	0.035
	(0.336)	(0.594)	(0.584)
$SADC$	0.867^a	1.178^a	1.170^a
	(0.146)	(0.190)	(0.191)
RTA^{Other}	0.025^a	0.259^a	0.245^a
	(0.053)	(0.036)	(0.035)
OBS	764314	835315	792200
R^2	0.990	0.990	0.990

Notes: ^{a},^{b} denote significance at the 1 and 5 percent level respectively. Robust clustered standard errors are reported under each coefficient. All regressions are estimates with the PPML estimator with exporter-time, importer-time effects and country-pair effects (f_{ot} , f_{dt} , f_{od}). Past agreements are introduced in Column 2, dummies of wars between partners and of GATT/WTO membership are introduced in Column 3. Coefficient of old RTAs, of wars and GATT membership are not reported here to provide a readable table. The dependent variable is trade flows in value from DOTS between 1962 and 2014.

4.2 Internal Trade and Time-Trend

In an important article, Bergstrand et al. (2015) show that the omission of time-varying bilateral costs is a serious problem in the estimation of RTAs. Consequently, they propose to introduce intranational trade along with a border dummy that varies over time. With the Melitz (2003)'s model as a guideline, they argue that a decrease in bilateral costs foster the entry of the most productive domestic firms on international markets due to a selection effect. On the opposite the number of firms that operates only on the domestic market decrease in reason of tougher competition. A decrease in bilateral trade costs, can thus lead to an increase in international trade relatively to intranational trade. Without a time-varying bilateral variables that capture these effects, the coefficient of RTA is biased upward.

Putting differently, RTAs may have the tendency of diverting internal towards international trade. We thus follow this article by estimating our gravity equation (4) by adding intranational trade flows. These flows comes from the EORA input-output tables, which is a multi-country matrix aggregated over 26 sectors of activity[13] during the period 1990-2015. EORA is divided into four blocks (transactions, value added, emissions associated with production and final demand) from which we use domestic final demand for domestic goods (we exclude change in inventories because they are related to unsold goods). Using these data for Africa is a delicate choice, indeed these flows are certainly a crude approximation of real internal flows due to error in the measurement of the domestic demand, but there is unfortunately no alternative choice.

We also modify our vector of time-varying bilateral control by adding the Bergstand et al. (2015)'s dummy of border, here called $Bilateral_{od}$ that takes 1 when the source o and destination d countries are different and 0 when countries o and d are the same. We then interact this variable with a set of year dummies creating a set of time-varying bilateral control, namely $Bilateral_{odt}$. Since there is no data on internal flows before the 90s, we do not introduce here past African RTAs.

Our time-varying bilateral variables used in the estimation of (4) are thus:

$$\phi_{odt} = \lambda.RTA^{Other}_{odt} + Bilateral_{odt} + GATT_{odt} + WAR_{odt}. \quad (7)$$

Alternatively we use the random trend model (see Wooldridge, 2010) in which we interact the bilateral fixed effects (od) with a time trend (Trend):

[13] See https://worldmrio.com/eora26/ for further details about sectoral aggregation and the structure of EORA26

$$X_{odt} = \exp\left[\alpha + f_{ot} + f_{dt} + f_{od} * Trend + \phi_{odt}\right] + \epsilon_{odt}, \qquad (8)$$

where ϕ_{odt} is given by Equation (6).

Since the data on internal trade starts in 1990, before to investigate this new empirical strategy, we run again the previous estimations but on the period 1990-2014 instead of 1962-2014. Thus in Column 1 of Table (5) we report results with the OLS-FE including importer-time, exporter-time and bilateral fixed effect. In Column 2, results are obtained with our baseline estimation using PPML-FE on a sample of trade flows between 1990-2014.

The OLS-FE model provides similar results than before. Using the PPML-FE on this period leads to conclude that some agreement are not significant, or have a smaller impact during that period of time (e.g. ECOWAS, WAEMU). In Column 3 we introduce only the border variable, $Bilateral_{odt}$, in a PPML-FE estimation that include only importer fixed effect, exporter fixed effect, and bilateral fixed effect. Results are similar to those reported in Column 2. Only COMESA remains significant with a coefficient of 0.455. Finally in Column 4, we use the Random Trend model which reduces the coefficient of the COMESA around 0.2. In Column 5 we add the time-varying variables of wars and GATT/WTO membership. This introduction does not change the conclusion reached until now: on the most recent period going from 1990 to 2014, the effects of RTAs in Africa have been low and in most cases not significantly different from 0.

Table 5: RTAs in Africa

Control	OLS-FE	PPML-FE	Border	Random Trend	+WTO + War
EAC	1.495[a]	0.215	0.274	-0.228	-0.196
	(0.275)	(0.235)	(0.217)	(0.147)	(0.116)
$COMESA$	0.757[a]	0.446[a]	0.455[b]	0.208[a]	0.223[a]
	(0.123)	(0.141)	(0.212)	(0.079)	(0.073)
$WAEMU$	0.526	0.209	0.344	-0.256	-0.249
	(0.436)	(0.185)	(0.332)	(0.148)	(0.153)
$ECOWAS$	0.959[c]	-0.351	0.521	0.055	0.124
	(0.535)	(0.255)	(0.555)	(0.263)	(0.253)
$CEMAC$	0.097	0.269	0.079	-0.410	-0.411
	(0.369)	(0.289)	(0.275)	(0.239)	(0.250)
$SADC$	0.628[a]	0.435[a]	0.109	0.090	0.026
	(0.145)	(0.134)	(0.155)	(0.109)	(0.092)
RTA^{Other}	0.410[a]	-0.085	0.164	0.042[b]	0.056[a]
	(0.047)	(0.057)	(0.095)	(0.019)	(0.020)
OBS	329686	418697	384953	418697	380837
R^2	0.878	0.992	0.982	0.997	0.9973

Notes: [a],[b] denote significance at the 1 and 5 percent level respectively. Robust clustered standard errors are reported under each coefficient. In Column 1 we use the OLS-FE model, in Column 2 the PPML-OLS model with importer-time, exporter-time and country-pair fixed effects (f_{ot} , f_{dt} , f_{od}). Regressions in Column 3 are done with the PPML estimator and with importer, exporter and country-pair fixed effects (f_o , f_d , f_{od}) and with a border variable. Regressions in Column 4 and 5 are done with the Random Trend Model with importer-time, exporter-time and country-pair-time effects (f_{ot} , f_{dt} , $f_{od} * Trend$). Dummies of wars between partners and of GATT/WTO membership are introduced in Column 5. International trade flows comes from the DOTS and intranational flows from EORA. The time period for all these regressions is 1990-2010.

5 A Simple General Equilibrium Analysis

As we have seen in the previous section, depending on the database, estimator and empirical strategy used, very different results are obtained regarding the estimation of λ. The question we ask here is: do these differences matter in general? Indeed the estimates that we have directly interpreted until now are comparative analysis obtained under the assumption that everything else is equal (in particular all the variables capture in fixed effects and country-time effects) such as preferences, technologies, wages and prices. They also provide results about trade creation, but not about the trade diversion effects that RTAs inevitably imply. It is for instance possible that the relatively high estimation of λ obtained provides the same results in terms of welfare than smaller coefficients due to different general equilibrium effects, or due to trade diversion. Trade flows between members of the RTAs may be relatively too small to generate significant effects whatever the value of λ.

To analyze whether the strong heterogeneity obtained during all this paper really matters, or whether it has no consequence, we need to use a general equilibrium model. We chose the simplest model of the New Trade Quantitative Models (NTQM) based on Anderson and van Wincoop (2003) and Arkolakis et al. (2012) because this model requires only trade flows, GDPs and the estimates of only one parameter, the estimation of λ which is the central piece of the current study, to assess the effect of RTAs.

5.1 Scenarios

The NTQM is used to compare the effect of RTAs obtained from the meta-analysis, with the one we get with the most standard estimation of the structural gravity equation (i.e. PPML estimator, based on DOTS, with bilateral fixed effects and country-time varying effect), and finally with the internal flows and a time-trend.

From the meta-analysis, we use the coefficient obtained with the PPML estimator reported in Table (2). We call "baseline" the result based on our estimates of λ with the PPML estimator presented in Table (4, Column 1). The choice of the PPML estimator, while not perfect and raising issues when non reported data are replaced by zeros[14], is done in reference of the literature. As shown by Weidner and Zylkin (2020), PPML is the only non-linear estimator that does not face an incidental parameter problem (at least for large T) in the three-way fixed effects gravity setting (see also Santos Silva and Tenreyro, 2015). Finally regarding estimations with internal trade flows and a time trend, our preferred estimation is provided by Table (5, Column 5). We report below these estimation of λ when significant (written n.s. otherwise).

[14]Martin (2021) shows that many estimators, including the PPML estimator, are biased because dependent variables are limited-dependent and because non reported data are frequently replaced by zeros.

Table 6: RTAs in Africa

	Meta	Baseline	Preferred
$COMESA$	0.537	0.848	0.208
$ECOWAS$	0.729	0.579	$n.s.$
$SADC$	0.693	0.867	$n.s.$
EAC	0.294	$n.s.$	$n.s.$
$CEMAC$	$n.s.$	$n.s.$	$n.s.$
$WAEMU$	$n.s.$	$n.s.$	$n.s.$

Notes: in Column 1, coefficients of RTAs comes from the meta-analysis based on studies using the PPML estimator. Column 2, from the estimation of the structural gravity equation with PMML and with importer-time, exporter-time effects and country-pair fixed effects. Column 3 with the Random Trend Model. All these coefficients are significant (1 percent level). Non significant coefficients are represented by "$n.s.$".

Table (6) that summarizes what we have learn so far, is quite devastating, once the most sophisticated gravity equation is estimated on African trade, only the COMESA is significant. There is thus no reason to analyze the general equilibrium effect of λ when we consider that this coefficient is not significantly different to zero. Since our aim is to compare the effects of different RTAs elasticities, we focus our analysis on the COMESA and we study three different scenario, using successively $\lambda = 0.848$, $\lambda = 0.537$ and $\lambda = 0.208$. We report in the Online Appendix E, simulations for other agreements.

5.2 The model

The model is here based on Anderson and van Wincoop (2003), then generalized by Arkolakis and al. (2012). We follow here the presentation of this model done by Head and Mayer (2014) for its clarity.

The model is based on Dixit-Stiglitz preferences, a linear costs functions with only one factor of production (labour), a complete specialization and iceberg trade costs.The gravity equation takes the following form:

$$X_{od} = \phi_{od} \frac{Y_o}{\Pi_o^{1-\sigma}} \frac{Y_d}{P_d^{1-\sigma}} \tag{9}$$

where σ is the elasticity of substitution between varieties ($\sigma > 1$), ϕ_{od} an unversed measure of trade costs τ_{od} ($\phi_{od} = \tau_{od}^{1-\sigma}$i.e an indicator of trade openness) between o and d, Y_d and Y_o the aggregated expenditures/incomes at the destination of exports d and at origin o. $\Pi_o^{1-\sigma}$ represents the market potential in o. This term is sometimes considered as an indicator of the market access from o and/or called outward multilateral resistance because it represents a GDP share weighted measure of trade cost resistance that exporters in o face when shipping their goods to consumers on their own and outward markets. Concerning African RTAs, this term may matter since the recent History of Africa (e.g. slavery, colonialism, preferential trade agreements[15]) has affected bilateral trade costs between African countries *relatively* to trade costs with distant countries. The term $P_d^{1-\sigma}$ in this gravity equation (9) is the accessibility-weighted sum of exporters-o capabilities also called inward multilateral resistance since it is a reversed measure of the openness of a nation to import from the world. Anderson and Yotov (2010) also consider this term as the buyer's incidence because it represents the weighted sum of trade costs paid by buyers.

The real market potential of exporters in this structural gravity equation is defined by:

$$\Pi_o \equiv \left[\sum_{d=1}^{n} \left(\tau_{od}/P_d \right)^{1-\sigma} Y_d \right]^{1/1-\sigma} \tag{10}$$

while the price index of the consumption basket in the destination country is given by:

$$P_d \equiv \left[\sum_{o=1}^{n} \left(\tau_{od}/\Pi_o \right)^{1-\sigma} Y_o \right]^{1/1-\sigma} \tag{11}$$

Considering a Log-differentiation of the gravity equation (9) we present, hereafter and step by step, the impact of a change in trade costs due to RTAs. Starting by analyzing a change of trade costs ϕ_{od} in the numerator of (9), from ϕ_{od} to ϕ_{od}^c, we obtain the direct effect of trade costs. The upper-script c is used to characterize the counterfactual experiment. Assuming the part of trade costs related to RTAs is a linear function of $\ln \phi$ with a coefficient ψ, we can write the *direct* effect of the enforcement of RTA on bilateral trade

[15]The first Generalized System of Preferences were non-reciprocal schemes implemented by the European Economic Community and Japan in 1971 and by the USA in 1976, i.e. only a few decades after the wave of Independence, to facilitate LDCs access to markets of rich countries. See Candau and Jean (2009) for a detailed analysis on the utilization of these trade preferences in Africa.

flows in a very simple form:

$$Direct_{od} \equiv \dot{\phi}_{od} = \frac{\phi^c_{od}}{\phi_{od}} = \exp\left[\psi\left(RTA(1)_{od} - RTA(0)_{od}\right)\right], \tag{12}$$

where $RTA(0)$ means no RTA and $RTA(1)$ enforcement. The "dot" is used in this paper to represent the proportional change in a variable between its initial value and the counterfactual scenario.[16] As shown in this equation (12), the direct effect does not take into account price indices.

Now adding in this analysis how multilateral resistances vary after regional trade liberalization gives what we called the *Price Index Effect* of RTAs[17]:

$$PIE_{od} \equiv \frac{\Pi_o P_d}{\Pi^c_o P^c_d} \exp\left[\lambda\left(RTA(1)_{od} - RTA(0)_{od}\right)\right]. \tag{13}$$

An important advantage of the PIE is third-country effects are taken into account. One drawback is that expenditure and output are assumed constant for all countries. This is quite unrealistic, in particular when we consider a reduction in trade costs with partners specialized on the same goods, because due to competition, this integration would certainly not leave incomes unchanged. To sum up, in comparison to the direct effect, the PTI takes into account the competition effect of RTAs that transits by the price index, but not the effect on income.

To compute this PIE, we set the value of the trade elasticity, hereafter denoted $\widehat{\lambda}$ and presented in Table (6), to compute ϕ_{od} such as $\phi_{od} \equiv \exp[\widehat{\lambda} RTA_{odt}]$. Using this measure of ϕ_{od} with expenditures Y_o and Y_d in Equation (10) and (11) with the contraction mapping of Head and Mayer (2014) gives the multilateral resistances Π_o and P_d.

Then using these measures of ϕ_{od}, we get from Equation (12) the counterfactual trade costs ϕ^c_{od}, i.e. $\phi^c_{od} \equiv \phi_{od} \exp\left[\widehat{\psi}\left(RTA(1)_{od} - RTA(0)_{od}\right)\right]$. Using again the contraction mapping with ϕ^c_{od} and with the same expenditures Y_o and Y_d provides the counterfactual multilateral resistances Π^c_o and

[16] The literature usually work with a "hat", a notation here preserved to notify the predicted value of coefficients.

[17] Head and Mayer (2014) call this effect the Modular Trade Impact in reference to Anderson (2011).

P_d^c. All these findings give the *PIE* of RTAs presented in Equation (13).

However one important aspect of trade liberalization has been neglected: the impact of RTAs on wages/incomes. Taking into account this change, the General Equilibrium Trade Effect (GETI), is defined as follows:

$$GETI_{od} = \frac{Y_o^{'} Y_d^{'}}{Y_o Y_d} \frac{\Pi_o P_d}{\Pi_o^c P_d^c} \exp\left[\psi\left(RTA(1)_{od} - RTA(0)_{od}\right)\right]$$

Where $Y_o^{'}$ and $Y_d^{'}$ denote respectively the production in origin country and the expenditures in destination country after trade costs changes. Considering the production side with labour as the sole factor of production in each country $i = (o, d)$, $Y_i = w_i L_i$, and by considering change in the labour force as constant, then changes in incomes are determined by changes in wages $\dot{w} = \dot{Y}$). Since trade deficit are constant, change in expenditures equals change in incomes. To determine the equilibrium change in income we use the share of expenditure of consumers in o spent on goods produced in d, $\pi_{od} = Y_{od}/Y_o$. Finally, the change in expenditure due to a trade shock is given by:

$$\dot{\pi}_{od} = \frac{\dot{\phi}_{od} \dot{Y}_o^{1-\sigma}}{\sum_l \pi_{ld} \dot{\phi}_{ld} \dot{Y}_l^{1-\sigma}}. \tag{14}$$

Inserting this expression in the market clearing enables to solve the system and to get the income change due to the enforcement of a RTA:

$$\dot{Y}_d = \frac{1}{Y_d} \sum_{o=1}^{n} \frac{\pi_{od} \dot{\phi}_{od} \dot{Y}_o^{1-\sigma}}{\sum_l \pi_{ld} \dot{\phi}_{ld} \dot{Y}_l^{1-\sigma}} \dot{Y}_o Y_o. \tag{15}$$

Using the direct effects calculated earlier, with Y_o approximated by GDPs, and the trade share π_{od} of each country o, gives from (15) a system of equations defining $\dot{Y}_o$, which once inserting in the trade share expenditure (14)[18], gives the General Trade Equilibrium Impact (GETI) of trade shock: $\dot{\pi}_{od} \dot{Y}_d$.

[18] To resolve the system we need an estimate of the constant elasticity of substitution between variety, we use $\sigma = 4.03$ which is the number obtained in the meta-analysis of Head and Mayer (2014).

We also compute the welfare gains of RTAs under this quantitative exercise, given by $\dot{\pi}_{dd}^{1/(1-\sigma)}$, since welfare depends only on changes in the trade to GDP ratio.

To assess the removal impact of African RTAs, it is essential to have internal flows to measure domestic expenditures in order to re-calculate multilateral resistances and GDPs after a change in trade costs. As a consequence, we use the Input-Output Tables coming from EORA Database. This database contains the Input-Output tables for 195 countries.

6 Results

6.1 General Equilibrium Effects

Table (7) presents the PIE and GETI effects for the COMESA with the baseline estimate of λ (i.e. $\lambda = 0.848$), with the one obtained from the meta-analysis ($\lambda = 0.537$) and from our preferred estimation ($\lambda = 0.208$). The PIE and the GETI are computed at the bilateral level and in Table (7) we report the average effects of RTAs in % by country, with partners inside the COMESA (Column 1 and 4), outside the bloc (Column 2 and 5) and for all partners (Column 3 and 6).

At least three results are noteworthy. First, trade creation measured by the change in PIE and GETI inside COMESA (Column 1 and 4) has been strong. This result is obviously very clear when the values of λ are high ("baseline" and "meta" line) but even with the smallest value of λ ("preferred" line), the COMESA has succeeded to develop trade in the bloc. Moreover since the PIE is always smaller than the GETI for these intra-PIE and intra-GETI, one may conclude that general equilibrium effects included in GETI magnifies the gain of this trade creation.

The second result is the importance of trade diversion effect approximated by the change in PIE and GETI with countries outside COMESA (Column 2 and 5). The change in percentage is low (between 1.5% and 6%), however since this trade concerns more important flows (almost 95% of the total trade of the bloc), the effect can be significant. This is verified by looking at the global effect of RTA on change in PIE and GETI with all partners (Column

3 and 6), where the net effect of trade creation and diversion is positive, but however relatively small in comparison with the trade creation observed. Indeed in many countries, the COMESA has led to an increase in the GETI between 1% and 6% only (using the λ of the meta-analysis).

Interestingly, while in the literature the difference between the PIE and the GETI are often small for RTAs (according to Head and Mayer, 2014), here the gain from GETI is relatively high and comparable with the results obtained by the counterfactual removal of the US-CAN border (see Anderson and van Wincoop, 2003).

Finally, comparing the result obtained with the different RTAs trade elasticities show the importance to precisely measured λ since the general equilibrium results vary sharply for COMESA depending of the value used. For many countries the increase in the Intra PIE is around 55% with the coefficient obtained from the meta-analysis and almost twice higher with the coefficient get with the baseline estimation. Similarly trade diversion are much higher in the former case than in the later, and consequently the increase in the net PTI is around 4% with the meta-analysis but around 7% with the baseline estimations. The GETI results follows the same path, varying for instance from 5% to 10% for Djibouti.

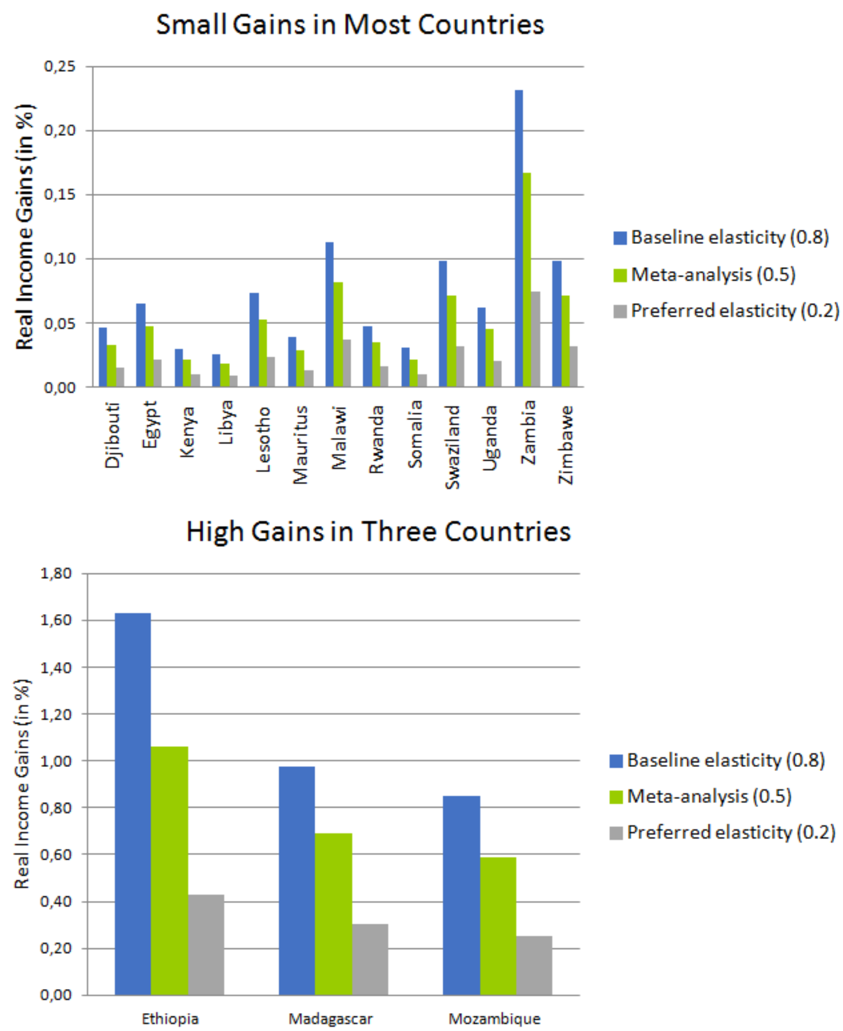
To conclude on these results, the three scenario provides a similar conclusion: the trade creation of the COMESA has been strong, but the trade diversion has reduced the total gains. The real income gains (see Figure 6.1) of COMESA are very low for most countries (i.e. below 0.25%). Only three countries have a clear benefit with 1.6% of income growth in Ethiopia, 1% in Madagascar and 0.8% in Mozambique in the most favorable scenario (baseline). With the smallest elasticity, the gain in these countries fall between 0.4% and 0.2%.

Table 7: COMESA

		PTI			GETI		
		Intra	Extra	All	Intra	Extra	All
Djibouti	Baseline	100.6	-2.6	7.2	112.1	0.2	10.9
	Meta	55.8	-1.5	4	59.7	0.2	5.8
	Preferred	18.9	-0.5	1.35	19.4	0.07	1.92
Egypt	Baseline	106.4	-3.3	7.7	120.1	0.3	11.7
	Meta	59.2	-1.8	4	64	0.2	6.3
	Preferred	20.0	-0.63	1.34	20.8	0.09	2.07
Ethiopia	Baseline	107.4	-2.8	7.1	101.1	-8.3	2.2
	Meta	59.6	-1.6	4.3	54.7	-5.4	0.3
	Preferred	20.20	-0.54	1.44	18.03	-2.21	0.27
Kenya	Baseline	106.3	-3.3	7.1	119.1	-0.1	11.3
	Meta	59.1	-1.9	3.9	63.5	-0.1	6
	Preferred	20.08	-0.64	1.33	20.65	-0.04	1.93
Libya	Baseline	100.4	-2.7	5.3	112.2	0.2	10.9
	Meta	55.7	-1.5	3.9	59.7	0.2	5.9
	Preferred	18.8	-0.52	1.33	19.44	0.07	1.92
Lesotho	Baseline	97.2	-4.4	4.4	111.2	-0.2	10.4
	Meta	54.6	-2.2	3.2	59.2	-0.2	5.5
	Preferred	18.8	-0.52	1.33	19.2	-0.06	1.78
Madagascar	Baseline	101.1	-5.9	4.4	139	8.4	20.8
	Meta	57.4	-3	2.8	73.4	5.7	12.2
	Preferred	20.06	-0.66	1.3	23.6	2.3	2.4
Mozambique	Baseline	101.3	-5.8	4.5	105.5	-6.3	4.4
	Meta	57.5	-2.9	2.9	56.4	-4.4	1.4
	Preferred	20.7	-0.64	1.3	18.4	-1.8	0.07
Mauritius	Baseline	104.1	-4.4	6	119.8	0.1	11.6
	Meta	58.6	-2.2	3.6	63.8	0.1	6.2
	Preferred	20.2	-0.5	1.4	20.7	0.04	2.0
Malawi	Baseline	103.3	-4.8	5.5	118	-0.7	10.7
	Meta	58.3	-2.4	3.4	62.8	-0.5	5.6
	Preferred	20.1	-0.5	1.4	20.4	-0.2	1.7
Rwanda	Baseline	106.1	-3.4	7	119.9	0.2	11.6
	Meta	58.9	-2	3.8	63.9	0.1	6.2
	Preferred	20.0	-0.6	1.4	20.7	0.05	2.0
Somalia	Baseline	106.1	-3.4	7	199.5	0	11.4
	Meta	59.1	-1.9	3.9	63.6	0	6.1
	Preferred	20.0	-0.6	1.3	20.7	-0.00	1.9
Swaziland	Baseline	104.1	-4.4	5.9	118.8	-0.3	11.1
	Meta	58.6	-2.2	3.6	63.3	-0.3	5.8
	Preferred	20.2	-0.5	1.45	20.5	-0.1	1.8
Uganda	Baseline	106.6	-3.1	7.3	119.7	0.1	11.5
	Meta	59.3	-1.8	4	63.7	0	6.1
	Preferred	20.1	-0.6	1.3	20.7	0.01	1.9
Zambia	Baseline	101.2	-5.8	4.4	117.9	-0.7	10.6
	Meta	57.4	-2.9	2.8	62.8	-0.5	5.5
	Preferred	20.6	-0.6	1.3	20.4	-0.2	1.7
Zimbabwe	Baseline	101.2	-5.8	4.4	107	-5.5	5.3
	Meta	57.5	-2.9	2.8	57.1	-3.9	1.9
	Preferred	20.0	-0.6	1.3	18.5	-1.7	0.2

Notes : Simulations done with a simple NTQM. The "baseline" scenario is based on a coefficient of COMESA equals to 0.848, obtained from the estimation of the structural gravity equation with PMML and with importer-time, exporter-time effects and country-pair fixed effects. The "meta" scenario is based on a coefficient of COMESA equals to 0.537, obtained from the meta-analysis of studies using the PPML estimator. The "preferred" scenario is based on a coefficient of COMESA equals to 0.208 obtained from the estimation of the structural gravity equation with a Random Trend Model including importer-time, exporter-time and country-pair-time effects.

Figure 5: African regionalism with different trade flow databases



Notes : Simulations done with a simple NTQM. The "baseline" scenario is based on a coefficient of COMESA equals to 0.848, obtained from the estimation of the structural gravity equation with PMML and with importer-time, exporter-time effects and country-pair fixed effects. The "meta" scenario is based on a coefficient of COMESA equals to 0.537, obtained from the meta-analysis of studies using the PPML estimator. The "preferred" scenario is based on a coefficient of COMESA equals to 0.208 obtained from the estimation of the structural gravity equation with a Random Trend Model including importer-time, exporter-time and country-pair-time effects.

7 Concluding remarks

After surveying the field on the gravity equation applied to African countries and by leading our own estimation, we conclude what is often asserted in "off" by experts but rarely written in plain: trade elasticities obtained for African countries are dubious. Some agreements that are known to be not fully implemented creates unrealistically high level of trade flows according to the gravity equation. Since trade data flows of African countries are notorious biased by bad reporting, we analyze how the results change by using different databases on which different corrections have been done by statistical institutes. We find some differences showing that the incomplete data on trade flows certainly pose a challenge to estimate with accuracy the effect of RTAs. However, the surprising high effect of RTAs seems to be more related to omitted variables than to omitted international flows. By introducing importer-time and exporter-time effects as well as country-pair fixed into a gravity equation estimated with PPML, we find that only ECOWAS, SADC and COMESA significantly foster trade. Finally, by introducing internal flows and time-trend, even ECOWAS and SADC become unsignificant. The coefficient of COMESA is the sole that remains different to zero, but falls from 0.8 to 0.2. We then propose to use these estimates to analyze how the trade effects of COMESA are influenced by the trade elasticity estimated. We find that whatever the trade elasticity, COMESA has created trade in the area, but has also a substantial level of trade diversion that has reduced the gains of the regional integration. We also show that the general equilibrium effects and the effect of the COMESA on welfare can be multiplied by three when the trade elasticity is multiplied by four. This last result reveals the importance to precisely measure the coefficient of RTAs.

The fact that the COMESA is the sole agreement which is significant may indicate that RTAs in Africa, which often concerns economies with similar specialization, need to reach a critical size to be effective. COMESA is indeed the largest FTA agreement in Africa. This is a good news for the the African Continental Free Trade Area (AfCFTA) within which fifty-five African countries envision to redefine their regionalization. According to a technical report of the World Bank (2020) "real income gains from full implementation of AfCFTA could increase by 7 percent by 2035, or nearly US$450 billion". The small effect of COMESA obtained here in terms of welfare indicate that such an aim, will required much more ambitious reforms to effectively reduce trade costs in Africa than the one put in place until now.

8 Online Appendix A (not for publication): A Brief Descriptions of RTAs in Africa

Economic Community of West African States (ECOWAS)

In West Africa, the largest regional initiative is the Economic Community of West African States (ECOWAS), created in 1975. This community counts 15 countries of relatively small size (11 countries on 15 are among the least developed countries, LDCs) at the exception of Nigeria which represents more than half of the total population and a significant proportion of the area's GDP. Since 1993-95, members shared a customs and currency union (CFA franc pegged on the euro). ECOWAS is composed of two sub-regional blocs (described below), the West African Economic and Monetary Union (WAEMU) and the West African Monetary Zone (WAMZ)

ECOWAS has developed significant ambitions, such as its objective to keep peace in the region (military operations in Liberia, Guinea-Bissau, and Sierra Leon), to establish an economic and social council, a court of justice and a parliament. However, the factual progress toward a deep integration has been laborious. In 1993 a customs union is signed by all members, the date to entry into force is enacted by 1995 and the full implementation is scheduled in 2000,[19] but the common external tariff has been delayed until 2015 and the common market is still in progress.

West African Economic and Monetary Union (WAEMU)

Within the ECOWAS, eight mainly francophone African states have formed the West African Economic and Monetary Union, WAEMU (also known

[19] All the dates of signature, dates of entry into force and implementation come from the WTO's page on RTAs: https://rtais.wto.org/UI/PublicMaintainRTAHome.aspx

as UEMOA from its French name, Union Economique et Monétaire Ouest Africaine), in 1994. The Ivory Coast is the biggest country in this group, followed by Senegal.

The origin of the WAEMU can be tracked back to the aftermath of the French colonization. After the independence, most of these countries kept their monetary union with France under the West African CFA (Financial Community of Africa) "Franc zone"[20] and have established different Regional Economic Communities (RECs) before the WAEMU. In 1959, a custom union, the UDAO is created but not enforced and soon replaced in 1966 by the UDEAO, itself replaced in 1973 by the CEAO (for Communauté Economique de l'Afrique de l'Ouest) that aim to promote a common market.

The WAEMU may be one of the most integrated RECs. Inspired by European common market, this REC has a common trade policy and a solidarity fund financed by 1% of the duties on imports from the rest of the world providing resources for a cohesion mechanism in order to reduce disparities within the region. However several anecdotal evidences illustrate that the the WAEMU is far from being fully integrated.

West African Monetary Zone (WAMZ)

the West African Monetary Zone (WAMZ), has been formed in 2000, by six countries of the ECOWAS (Gambia, Ghana, Guinea, Nigeria and Sierra Leone are the founding members, Liberia joined in 2010). The WAMZ has the objective to create a common currency based on a new currency, the Eco.

Economic and Monetary Community of Central Africa (CEMAC)

The Economic and Monetary Community of Central Africa (CEMAC) finds its origin in the Central African Customs and Economic Union, or UDEAC (Union Douanière et Économique de l'Afrique Centrale) from its name in French, established in 1964. An enlargement occurred in 1983 with members

[20] Composed of the WAEMU and of the Central African Economic and Monetary Community (CAEMC). The Franc Zone exists since 1939, but its reality goes back to the 19th century. See De Sousa and Lochard (2005) for a brief history and an analysis of the border effect puzzle in the CFA Franc Zone.

of the Economic Community of Great Lakes States (CEPGL, formed in 1976) in 1983, under the name of the Economic Community of Central African States (ECCAS).

But due to the lack of contributions of members and of conflict in the Great Lakes area, ECCAS has been ineffective leading members of the UDEAC to sign a deeper integration, with only six countries, the CEMAC in 1994 (Cameroon, Central African Republic, Chad, Congo, Equatorial Guinea, Gabon) and enforced in 1999. The CEMAC is a customs union with a common external tariff that began to be implemented in 2006.

East African Community (EAC)

The East African Community (EAC), founded in 1967 by the three countries of Kenya, Tanzania and Uganda, first collapsed in 1977 based on the idea that Kenya was taking the lion's share of the benefits of this RTAs. The new EAC enforced in 2000 by Kenya, Tanzania and Uganda and then by Rwanda and Burundi in 2007 and by South Sudan in 2016, became a fully-fledged Customs Union in 2009. This last agreement is often viewed as a successful experience of fast integration.

South African Development Community (SADC)

The South African Development Community (SADC) is a political association created in 1992 by fourteen members. This treaty has numerous binding protocols dealing with issues such as defense, development, migration and free trade. Before the SADC, a previous institution was built without South Africa and with the aim to counter-balance the power of this country. South Africa finally joined the SADC in 1994 and has taken a leading role in this REC. The RTA signed in 1996, entered into force in 2000 and ended its period of implementation in 2015.

Southern African Customs Union (SACU)

The Southern African Customs Union (SACU) is one of the oldest customs union in the world, formed in 1910 and updated in 1970. Namibia joined the SACU in 1990 after its independence from South Africa. Members of SACU are Botswana, Eswatini (formerly Swaziland), Lesotho, Namibia and South Africa.

Common Market for Eastern and Southern Africa (COMESA)

The Common Market for Eastern and Southern Africa (COMESA) is a very large free trade area with twenty-one member states formed in 1994 and replacing a Preferential Trade Area (PTA) which had existed since 1981. The period of implementation of the COMESA ended in 2000 and this community includes countries of the EAC and of the SADC. Some countries have even left the COMESA to join these RTAs.[21]

The Custom Union of the COMESA has been launched in 2009 and is far from being fully implemented. The report of the 2014 meeting of the Council of Ministers of the COMESA members notes little progress in enacting the Common Market legislation and reveals that only nine of 19 members had signed the COMESA Treaty (COMESA, 2014). Moreover on the twelve instruments enabling to implement this treaty between 2009 and 2012 only five had been ratified.

9 Online Appendix B (not for publication): Three Databases

By analyzing 1910 meta-analyses across different fields, Fanelli et a. (2017) observe that the heterogeneity of results (and of the publication bias) is higher in economics than in hard sciences. One of their explanation is related to data. As they argue in hard sciences, e.g. in physics, the sample size is large enough and the quality of data good enough to reduce the heterogeneity of results. Doucouliagos and Stanley (2013) have a similar argument by finding that inside economics, the publication bias is higher in macroeconomics than in other field in reason of selection bias in data. The (bad) quality and the heterogeneity of the databases used to study trade in Africa can also explain the heterogeneity of results presented until now. Thus, since to our knowledge

[21] Lesotho in 1997, Mozambique in 1997, Tanzania in 2000, Namibia 2004 and Angola in 2007

a comparative analysis of the results obtained with different databases has never been done, we propose to estimate Equation (4) with three different databases that are the most used in the literature, namely COMTRADE from the United Nations, DOTS from the IMF, and BACI from the CEPII.[22] These three databases are different in their contents because trade flows reported vary according to the correction done on import and export. In theory, exports from country A to country B equal import from B to A, but in practice this is not the case (for different reasons).[23] For instance, trade flows are sometimes reported by only one partner. Another case is when the volume of flows differs depending of the reporting of the exporter or of the importer. In these cases, it is possible to take advantage of the double information on each trade flow to fill out the matrix of bilateral world trade and to provide a "reconciled" value for each flow reported. Some databases are corrected by using this mirror technique, but other are not.

COMTRADE provides data that are directly reported by each country to the United Nations Statistical Division. There is no reconciliation between importers and exporters. In DOTS some corrections are done for non-reporting and slow-reporting countries. BACI reconciles more systematically the declarations of the exporter and the importer by using the mirror technique.

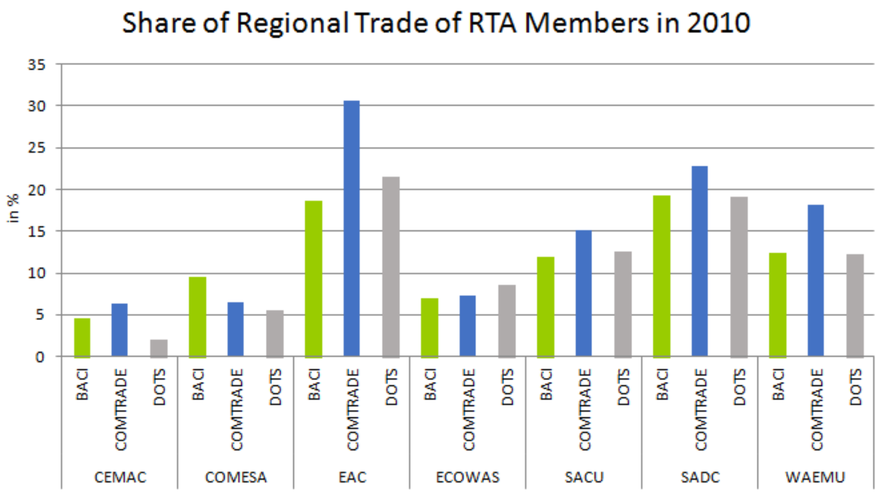
These corrections obviously have consequences. COMTRADE, a database without correction, almost systematically provides a higher share of intra-trade inside RTAs (see Figure 9). For instance, the share of the regional trade in CEMAC is twice higher with COMTRADE than with DOTS. Regarding COMESA while COMTRADE provides a share of regional trade at 30%, BACI gives a percentage below 20%. Since custom services are often more efficient in developed countries, an export from an African country to a developed country is easily corrected, but the technique of mirror flows

[22]Some other database are used, but less frequently. For instance Magee (2008) uses the Statistics Canada's World Trade Analyzer and Candau et al. (2019) use Tradehist, an historical data base on trade flows proposed by the CEPII.

[23]Import includes cost, insurance and freight, while exports are free on board, but also in reason of classification errors or of bad governance at the border enabling importers to understate the import value at customs clearance. See Jean et al. (2018) on customs duty evasion.

between African countries may be less reliable because both the exporter and the importer may face difficulty to correctly collect data.[24] This may explain why BACI and DOTS provide a smaller share of regional trade than COMTRADE.

Figure 6: African regionalism with different trade flow databases



Source: Authors's calculation based on COMTRADE (UN), DOTS (IMF) and BACI (CEPII). For each database we compute export of members inside their RTA divided by the total exports of each members.

The result can also be affected by the volumes of trade flows that are missing. Martin (2021) for instance considers that the missing trade for relatively small flows may bias gravity model coefficients up while missing trade for large flows may bias them down. If one assumes that in Africa, small flows are more likely to be unreported, it is possible that the effects of RTAs are overestimated.

Between the improvements brought by the different corrections and the bias introduced by the quality of the data reported, it is difficult to determine

[24] A second problem lies in the fact that in order to compare imports and exports, one needs to find the exact value of Cost, Insurance and Freight (CIF) because imports value are reported with CIF included while exports are reported FOB (free on board). To allow the comparison between mirror data, CIF rates have to be estimated and removed from imports values. To estimate CIF, statistical institutes use a gravity equation. Thus beyond the fact that by using these corrected trade flows we may introduce in the data some endogeneity bias, it is possible that CIF are badly approximated by this procedure.

what happen exactly in the data. It is for instance difficult to explain why BACI sometimes provides a higher level of regional trade than DOTS (for CEMAC or COMESA) and sometimes provides a smaller share (EAC or ECOWAS).

To conclude by working on RTA in Africa, we have to keep in mind that the data differ strongly from one database to another. This implies that the analysis of RTA in a gravity equation, which is all about trade between RTAs members relatively to trade with the rest of the world, can be affected by the database choice.

Then, to get a clearer picture, we estimate our gravity equation (4) with three databases, namely DOTS, COMTRADE and a third one that uses DOTS until 1993 and BACI from 1994.[25] The time period for these three databases is thus from 1962 to 2014. Results are reported below.

[25]BACI starts in 1994 which often leads researchers to focus on RTAs signed at least three or two years after that date to get some variation in the RTA's dummy. As illustrated in Table 1, since many RTAs are enforced in 1994, this database choice limits the number of RTAs studied. To make our analysis comparable over a long period of time we thus decide to use DOTS in complement to BACI before 1994.

Table 8: RTAs in Africa

Database:	DOTS		COMTRADE		DOTS+BACI	
Estimator:	FE	PPML	FE	PPML	FE	PPML
EAC	1.649[a]	0.388	1.440[a]	0.192	1.871[a]	0.444
	(0.310)	(0.357)	(0.391)	(0.337)	(0.318)	(0.300)
COMESA	0.895[a]	0.848[a]	0.808[a]	0.992[a]	1.008[a]	1.017[a]
	(0.110)	(0.175)	(0.131)	(0.195)	(0.100)	(0.199)
WAEMU	0.648[a]	0.636[a]	0.617[a]	0.844[a]	1.119[a]	0.724[a]
	(0.238)	(0.199)	(0.226)	(0.229)	(0.199)	(0.209)
ECOWAS	0.639[a]	0.579[b]	1.516[a]	1.495[a]	1.422[a]	1.019[a]
	(0.203)	(0.279)	(0.163)	(0.301)	(0.189)	(0.266)
CEMAC	-0.218	0.339	0.624	0.850[b]	0.358	0.594[b]
	(0.407)	(0.336)	(0.474)	(0.040)	(0.294)	(0.303)
SADC	1.196[a]	0.867[a]	1.001[a]	0.638[a]	1.305[a]	0.711[a]
	(0.172)	(0.146)	(0.211)	(0.190)	(0.157)	(0.158)
SACU			2.263[a]	0.812[b]	0.877[a]	-0.317[a]
			(0.668)	(0.357)	(0.327)	(0.109)
RTA^{Other}	0.334[a]	0.025[a]	0.383[a]	0.083[b]	0.342[a]	0.078[c]
	(0.032)	(0.053)	(0.030)	(0.040)	(0.025)	(0.044)
Constant	14.271[a]		14.486[a]		7.068[a]	
	(0.005)		(0.005)		(0.004)	
OBS	517381	764314	593134	927735	947687	950095
R^2	0.858	0.990	0.856	0.993	0.837	0.990

Notes: [a],[b] denote significance at the 1 and 5 percent level respectively. Robust clustered standard errors are reported under each coefficient. Every estimation has been done with importer-time and exporter-time effects and with country-pair effects (f_{ot} , f_{dt} , f_{od}). The database COMTRADE is compiled by the United Nations, DOTS by the IMF, BACI by the CEPII. The database "DOTS+BACI" uses the DOTS data from 1962 to 1993 and the BACI data from 1994 to 2014. The time period for all these regressions is 1962-2014.

In Column 1 and 2 of Table (3), we report the results using DOTS estimated successively with the FE model and with the PPML estimator. Column 3 and 4 reproduce these estimations on COMTRADE, and Column 5 and 6 on the combination of BACI and DOTS.

By comparing the results obtained with different estimators, we find that regional trade agreements have a smaller effect once we take into account heteroskedasticity and zero trade flows using a gravity equation with the PPML estimator. The trade effects of SADC and SACU, and to a lesser extent of ECOWAS, are strongly reduced. This result has been first emphasized by Santos Silva and Tenreyro (2006) concerning preferential trade agreements. However, this decrease in the coefficient estimated is not always verified, for example the coefficient of COMESA is almost unaffected.

Regarding the EAC, we verify that this agreement is significant by using the FE model in Column 1, 3 and 4 (as Mayer and Thoenig, 2016), but this

RTA lose its explanatory power with the PPML estimator (see Column 2, 4 and 6).

Finally we find very different results by comparing the elasticity obtained by using different databases. For instance ECOWAS has a twice bigger effect with COMTRADE and DOTS+BACI than with DOTS whatever the estimator used. For other agreements, results depend on the estimator used. For instance using the FE model, COMTRADE provides in general the smallest elasticity (for EAC, SADC, COMESA, WAEMU), but with PPML it is the DOTS database that gives this result (for CEMAC, COMESA, ECOWAS, WAEMU).

While the amplitude of the coefficient change from one database to another, several conclusions can be draw. First, when an agreement is significant with one database, it is also significant with the two other (excepted for CEMAC). Second, the DOTS database often provides the smallest elasticity with the PPML estimator and PPML gives smaller estimates of the coefficient of RTAs than the FE model. For this last reason, the analysis that follows is done on DOTS with the PPML estimator.

10 Online Appendix C (not for publication): PPML And Controls Under Different Databases

Table 9: RTAs in Africa

Database	DOTS		COMTRADE		DOTS+BACI	
Control	Past RTAs	+WTO+wars	Past RTAs	+WTO+wars	Past RTAs	+WTO+wars
EAC	0.337	0.284	0.355	0.461	0.478	0.464
	(0.342)	(0.360)	(0.404)	(0.435)	(0.327)	(0.340)
COMESA	0.674[a]	0.633[a]	0.874[a]	0.784[a]	0.969[a]	0.857[a]
	(0.258)	(0.244)	(0.236)	(0.194)	(0.221)	(0.204)
WAEMU	0.149	0.103	1.011[b]	1.197[a]	0.647[b]	0.810[a]
	(0.276)	(0.259)	(0.427)	(0.438)	(0.260)	(0.310)
ECOWAS	0.907[a]	1.052[a]	1.541[a]	1.539[a]	1.076[a]	1.116[a]
	(0.295)	(0.305)	(0.312)	(0.327)	(0.260)	(0.292)
CEMAC	0.076	0.035	0.227	0.235	0.546	0.392
	(0.594)	(0.584)	(0.291)	(0.271)	(0.349)	(0.337)
SADC	1.178[a]	1.170[a]	0.910[a]	0.873[a]	0.949[a]	1.003[a]
	(0.190)	(0.191)	(0.213)	(0.204)	(0.178)	(0.168)
SACU			0.810[b]	0.481[b]	-0.262[b]	-0.110
			(0.320)	(0.236)	(0.117)	(0.080)
OBS	835315	792200	927735	809386	950095	816747
R^2	0.990	0.990	0.993	0.992	0.990	0.990

Notes: [abc] denote significance at the 1, 5 and 10 percent level respectively. Robust clustered standard errors are reported under each coefficient. Individual and bilateral effects (f_{ot} , f_{dt} , f_{od}) are introduced in this last column as well as past agreements (such as the COMESA before the agreement of 1994, the EAC before 2000, etc.) but are not reported here to make the table readable.

11 Online Appendix D (not for publication): Fixed Effect Model (FEM) of the Meta-analysis

Table 10: : Results of the Meta-analysis with the Fixed Effect Model

RTAs	Estimators	Effects	P-value	Lower bound of 95% CI	Upper bound of 95% CI	Q-test (p-value)	Mean	Nb. Estim.
ECOWAS	PPML	0.918	0.000	0.811	1.024	0.000	0.617	5
	OLS	0.553	0.000	0.506	0.600	0.000	0.510	28
	FE	0.906	0.000	0.757	1.055	0.963	0.852	6
COMESA	PPML	0.805	0.000	0.708	0.901	0.000	0.480	10
	OLS	0.324	0.000	0.261	0.387	0.000	0.183	26
	FE	0.853	0.000	0.682	1.024	0.003	0.565	5
EAC	PPML	0.605	0.000	0.555	0.656	0.000	0.278	24
	OLS	0.259	0.000	0.165	0.353	0.000	0.158	16
	FE	0.274	0.000	0.240	0.308	0.000	0.145	52
CEMAC	PPML	-0.107	0.096	-0.234	0.019	0.000	-0.130	13
	OLS	0.881	0.000	0.680	1.082	0.851	0.777	5
	FE	-0.565	0.056	-1.143	0.013	0.400	-0.301	3
WAEMU	PPML	0.300	0.000	0.210	0.390	0.000	0.370	13
	OLS	0.990	0.000	0.791	1.188	0.995	0.990	2
	FE	0.823	0.000	0.698	0.948	0.465	0.687	9
SADC	PPML	0.867	0.000	0.797	0.936	0.000	0.659	12
	OLS	0.580	0.000	0.490	0.670	0.000	0.409	14
	FE	0.825	0.000	0.586	1.064	0.827	0.740	5
SACU	PPML	0.861	0.001	0.331	1.391	0.215	0.340	2
	OLS	0.799	0.061	-0.036	1.633	0.000	0.798	2
Overall		0.135	0.000	0.131	0.140	0.000	0.119	423

12 Online Appendix E (not for publication): Simulations for ECOWAS and SADC

We use here the NTQM to study the general equilibrium effect of ECOWAS and SADC using the estimates of λ presented in Table (6, Column 1 and 2).

Table 11: ECOWAS

		PIE			GETI		
		Intra	Extra	All	Intra	Extra	All
Benin	Meta	92.1	-2.3	5.1	99.3	0	7.8
	Baseline	67.2	-2.0	3.5	72.5	0	5.7
Burkina	Meta	92.1	-2.3	5.1	99.5	0.1	7.9
	Baseline	67.2	-2.0	3.5	72.7	0	5.8
Côte d'Ivoire	Meta	92.2	-2.2	5.2	99.4	0	7.8
	Baseline	67.4	-1.9	3.6	72.6	0	5.7
Cap verde	Meta	92.1	-2.3	5.1	101.1	0.8	8.7
	Baseline	67.7	-1.7	3.8	73.9	0.7	6.4
Ghana	Meta	92.6	-2	5.4	99.1	-0.1	7.7
	Baseline	68.0	-1.5	3.9	72.5	-0.1	5.6
Guinea	Meta	92.7	-2	5.4	99.4	0	7.9
	Baseline	68.0	-1.5	4.0	72.7	0	5.7
Gambia	Meta	92.1	-2.3	5.1	99.2	-0.1	7.7
	Baseline	67.7	-1.7	3.8	72.5	-0.1	5.6
Liberia	Meta	92.3	-2.2	5.2	99.1	-0.1	7.7
	Baseline	67.8	-1.6	3.8	72.4	-0.1	5.6
Mali	Meta	92.1	-2.3	5.1	98.4	-0.4	7.3
	Baseline	67.3	-1.9	3.5	71.9	-0.4	5.3
Niger	Meta	92.6	-2	5.4	98.9	-0.2	7.6
	Baseline	67.8	-1.6	3.9	72.3	-0.2	5.5
Nigeria	Meta	92.2	-2.2	5.2	99.3	0	7.8
	Baseline	67.7	-1.7	3.8	72.6	0	5.7
Senegal	Meta	92.1	-2.3	5.1	98.8	-0.2	7.5
	Baseline	67.3	-1.9	3.5	72.2	-0.2	5.5
Sierra Leone	Meta	94.5	-1.1	6.3	98.6	-0.4	7.4
	Baseline	69.1	-0.8	4.6	72.0	-0.3	5.4
Togo	Meta	92.2	-2.2	5.2	98.6	-0.4	7.4
	Baseline	67.3	-1.9	3.5	72.1	-0.3	5.4

Table 12: SADC

Iso_o		PIE Intra	PIE Extra	PIE All	GETI Intra	GETI Extra	GETI All
Angola	Meta	79.7	-2.4	3.1	60	-13.4	-8.4
	Baseline	105.7	-3.2	4.1	81.2	-16.4	-9.8
Botswana	Meta	72.9	-1.9	3.1	100.8	11.5	17.5
	Baseline	96.8	-2.5	4.2	142.3	14.6	23.2
Lesotho	Meta	71.6	-2.7	2.3	77.6	-0.1	5.1
	Baseline	93.6	-4.3	2.3	107.3	-0.2	7.1
Madagascar	Meta	77.8	-3.5	1.9	108.9	11.3	17.9
	Baseline	100.7	-5.8	1.4	152	13.7	23.1
Mozambique	Meta	77.9	-3.5	2	76.9	-5	0.5
	Baseline	101	-5.6	1.5	106.1	-5.9	1.6
Mauritus	Meta	79.3	-2.6	2.9	86.8	0.3	6.1
	Baseline	103.6	-4.2	3	120	0.4	8.4
Malawi	Meta	79	-2.9	2.6	85.8	-0.2	5.6
	Baseline	102.9	-4.7	2.6	118.7	-0.2	7.8
Swaziland	Meta	79.3	-2.7	2.8	85.6	-0.3	5.5
	Baseline	103.7	-4.3	3	118.5	-0.3	7.7
Tanzania	Meta	80.4	-2.1	3.5	86.2	0	5.8
	Baseline	106.8	-2.7	4.6	119.3	0	8.1
South Africa	Meta	80.1	-2.2	3.3	82.7	-1.8	3.9
	Baseline	106.3	-2.9	4.4	114.3	-2.1	5.7
Zambia	Meta	77.8	-3.5	1.9	94.8	4.2	10.3
	Baseline	100.8	-5.7	1.4	131.5	5.1	13.6
Zimbabwe	Meta	77.8	-3.5	2	78.7	-3.8	1.7
	Baseline	100.8	-5.7	1.4	108.7	-4.6	3

13 Appendix A: acronyms

- CEPGL: Economic Community of Great Lakes States
- COMESA: Common Market for Eastern and Southern Africa
- EAC: East African Community
- ECCAS: Economic Community of Central African States
- ECOWAS: Economic Community of West African States
- UDEAC: Union Douanière et Économique de l'Afrique Centrale. In English UDEAC means Central African Customs and Economic Union. WAEMU: West African Economic and Monetary Union
- WAMZ: West African Monetary Zone

- SADC: South African Development Community
- SACU: Southern African Customs Union

14 Appendix B: Studies of the meta-analysis

The meta-analysis is based on 22 articles among which 15 have already be presented and are referenced in the bibliography: Carrere (2004, 2013), Cernat (2001), Cissokho et al. (2013), Djoumessi and Bala (2017), Elbadawi (1997), Guepie and Schlick (2019), Inancli and Addi (2019), MacPhee and Sattayanuwat (2014), Mayer and Thoenig (2016), Magee (2008), Musila (2005), Ngepah and Udeagha (2018), Nguyen (2019), Subramanian and Tamirisa (2001).

Seven articles have not been presented in the text:

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