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**IN GRAVITY NO VERITAS:  
DUBIOUS TRADE ELASTICITY  
AND WEAK EFFECTS OF  
REGIONAL TRADE AGREEMENTS  
IN AFRICA**

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

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## 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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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.<sup>1</sup> Starting from the fact that trade between African countries only represents small part of their exchange with the world<sup>2</sup> 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 find surprisingly high impacts. 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

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<sup>1</sup>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.

<sup>2</sup>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, insignificant 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, indeed several databases of trade flows are used in the literature and missing trade flows, that are numerous for African countries, are corrected differently from one database to another (no correction in COMTRADE, light correction in DOTS, significant curation in BACI). We also analyze how estimates change according to the estimator used. Finally we introduce much more control than the literature to take into account omitted variables such importer-time, exporter-time effects, bilateral fixed effects, bilateral time varying variables, and finally a bilateral trend with intranational flows. With this successive introduction progressively almost all the RTAs become insignificant, 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 that, like RTAs, varies over time, 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 affect the general equilibrium effect of the implementation 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 of this agreement, the 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 favourable 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 these 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. Section 6, the result of the NQTM with the different elasticity of trade of COMESA are presented and discussed. 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 A Brief History of RTAs in Africa

We present here a brief history of RTAs in Africa by describing past agreements that have led to the current regionalization of Africa. Date of signatures and entry into force of RTAs are presented in Table (1). To present the potential of these RTAs, we describe in Figure (2.1) the aggregated tariffs between members of each RECs just before the implementation of RTAs at the sectoral level. Tariffs for WAEMU in 1994 and ECOWAS in 1975 are not available for all countries and are thus not reported.

Data on tariffs 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
<i>EAC</i>	FTA	1999	2000*
	CM&CU	2009	2010
<i>COMESA</i>	CU	1993	1994*
<i>WAEMU</i>	FTA	1993	1994*
	CU	2000	2004
<i>ECOWAS</i>	FTA	1975	1975*
	CU	1993	1995
<i>CEMAC</i>	CU	1994	1999*
<i>SADC</i>	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.

### 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.

The ECOWAS has developed significant ambitions, such as its objective to keep peace in the region (military operations in Liberia and Sierra Leone), 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,<sup>3</sup> but the common external tariff has been delayed until 2015 and the common market is still in progress. For instance, surveys on firms reveal that despite the *de jure* total exemption of customs taxes and duties inside the bloc, 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 liberalised since 1993, these goods were still taxed inside ECOWAS in 2011.

<sup>3</sup>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>

## **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 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”<sup>4</sup> 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. Furthermore many Non-Tariff Barriers (NTBs) are known to limit trade in this zone (see de Melo and Nicita, 2018).

## **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 (CACEU) established in 1964. The CEMAC has been signed by six countries 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. As illustrated in

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<sup>4</sup>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 Locharde (2005) for a brief history and an analysis of the border effect puzzle in the CFA Franc Zone.



Figure (2.1), these countries imposed tariff barriers to their regional partners between 5% and 15% before the implementation of the CEMAC. While some members imposed higher tariffs often exceeding 20% for Foods, Fishing and Manufacturing goods, the average level of tariffs is low, indicating that the potential gains of a reduction of them are limited.

### **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, which became a fully-fledged Customs Union in 2009, adopts a more optimistic point of view by considering this regional integration as mutually beneficial. This last agreement is often viewed as a successful experience of fast integration. Figure (2.1) shows that the degree of trade integration measured by tariffs was already high before the entry into force, with tariffs that are in many sectors around 5%.

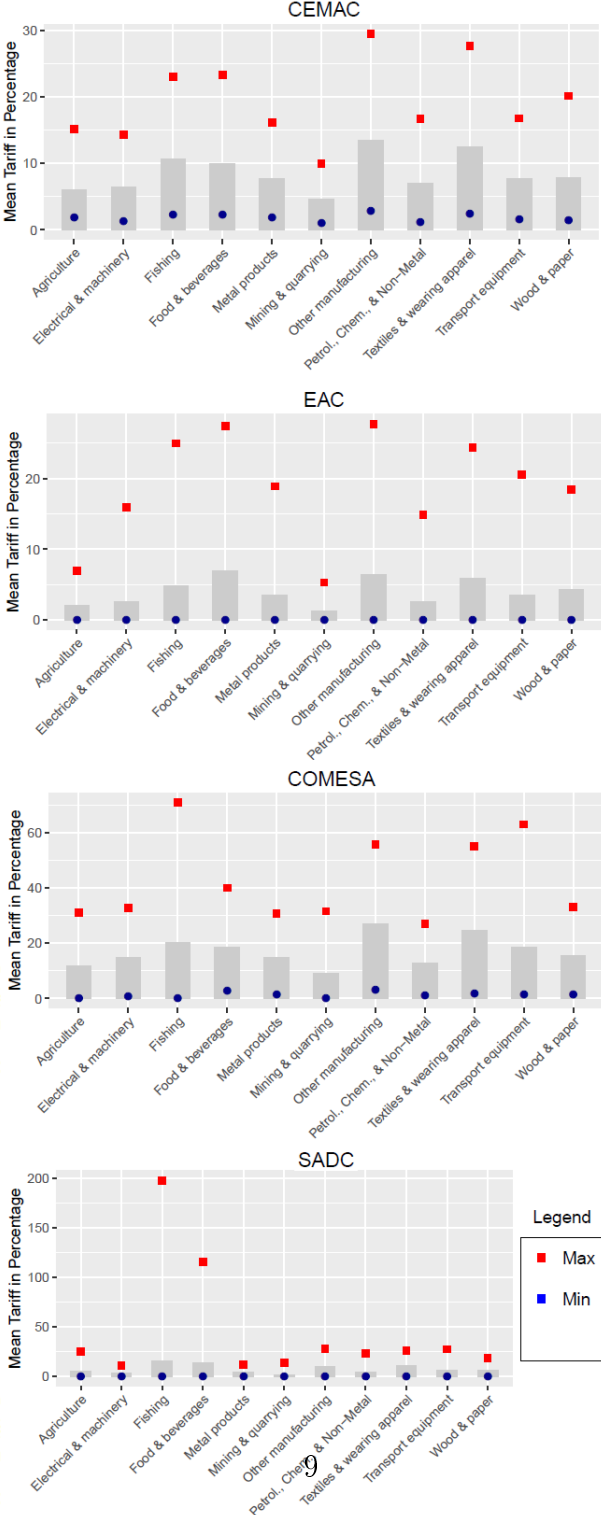
### **South African Development Community (SADC)**

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. Tariff rates between members of the SADC were already relatively small before the signature (namely in 1995), with however a significant heterogeneity in specific sectors with tariff peaks in Fishing, Food and Beverages.

## **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 the majority of countries belonging to the SADC. 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. Goods in several sectors were taxed around 10% (Fishing, Foods & Beverages, Manufactures, Textiles & Wearing Apparel), but in some countries the tariff rate reached 60% (see Figure 2.1).

Figure 1: 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. *Mean* is the average of tariffs inside the bloc. Tariffs at the goods level are weighted by the total imports of each country. 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).

## Concluding remark

The current RTAs come from a long history that, in many cases, began decades ago. In spite of tariffs peaks set to protect a specific sector, the average level of applied tariffs was quite low, often below 10%. This implies that, in general, we cannot expect a lot of the effect of RTAs on trade, at least with a trade liberalization limited to tariffs. Obviously, RTAs are not about tariffs only. The gravity equation is precisely the best tools to capture all other costs by inferring the effects of RTAs from trade flows.

## 2.2 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 manuscript on Google Scholar. We have found 22 published and unpublished articles which gives a database of 423 estimates (see Appendix A 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:

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

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”, mainly used before the Anderson and van Wincoop (2003) article, has well-known drawbacks. Baldwin and Taglioni (2007) deliver a “gold medal” mistake for this kind of regressions that do not control for exporter and importer unvarying factors. Head and Mayer (2014) conclude that this regression provide estimates that are biased towards zero.

We classify in the FE category, all the studies that used the OLS estimator but 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 studies using the PPML estimator 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 used in the literature 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  $\lambda$  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:

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

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 Appendix A 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 estimators, 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 FE model (0.906), while results with the OLS estimator 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). Sissokho and Seck (2012) even find (using the PPML estima-

tor) 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) find 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**

Constrasting 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 find that this REC has created a significant amount of trade between partners. Nguyen (2019) find a similar results, but once controls for bilateral relationships (using pair-fixed effects) are introduced, this RTA become insignificant 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 insignificant (and in some cases, significantly 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; Sawkut, 2006). 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 contradictionary 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  $\lambda$  are six time smaller than the one obtained with the FE model. Once again, estimations with the PPML estimator provide an intermediate value of 0.537 (raising intra-trade by 71%).



Table 2: A meta-analysis of African RTAs

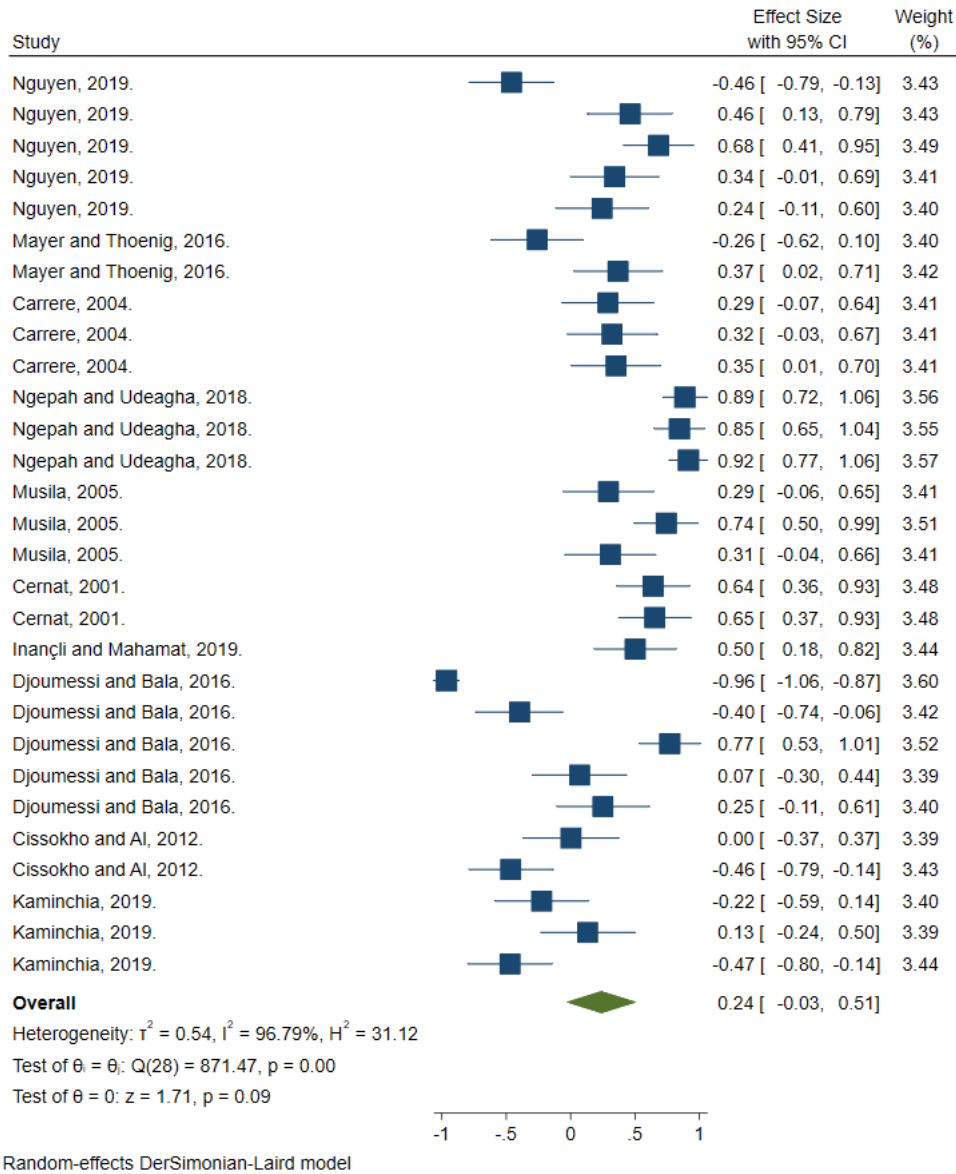
RTAs	Estimators	Effects	P-value	Lower bound of 95% CI	Upper bound of 95% CI	Nb. Estim.
ECOWAS	PPML	0.729	0.000	0.397	1.061	5
	OLS	0.514	0.000	0.319	0.709	28
	FE	0.906	0.000	0.757	1.055	6
COMESA	PPML	0.537	0.000	0.261	0.813	10
	OLS	0.195	0.039	0.010	0.381	26
	FE	0.672	0.001	0.277	1.067	5
EAC	PPML	0.294	0.009	0.073	0.515	24
	OLS	0.165	0.310	-0.153	0.482	16
	FE	0.164	0.001	0.064	0.264	52
CEMAC	PPML	-0.134	0.438	-0.471	0.204	13
	OLS	0.881	0.000	0.680	1.082	5
	FE	-0.565	0.056	-1.143	0.013	3
WAEMU	PPML	0.375	0.106	-0.079	0.830	13
	OLS	0.990	0.000	0.791	1.188	2
	FE	0.823	0.000	0.698	0.948	9
SADC	PPML	0.693	0.000	0.493	0.893	12
	OLS	0.424	0.005	0.129	0.718	14
	FE	0.825	0.000	0.586	1.064	5
SACU	PPML	0.679	0.190	-0.336	1.695	2
	OLS	0.799	0.061	-0.036	1.633	2
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.

### Concluding remark

By surveying the literature in this section, we have seen that the different studies often present ambiguous results. While some studies obtain strong and significant evidence of trade creation, other present insignificant results. The forest plot (2.2), done on specification that gives the highest  $R^2$ , illustrates this strong heterogeneity, showing estimates for the COMESA that are between -1 and 1.

Figure 2: 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 effects of RTAs on African trade.

The result varies according to the RTA considered. 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.

However, the current meta-analysis helps us to conclude that, for ECOWAS, COMESA and SADC, studies using the PPML estimator provide coefficients of RTAs between 0.5 and 0.8. This result is worth comparing with what has been obtained for RTAs in the rest of the world, in particular with respect to NAFTA and to the EU. 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 seem to 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 database, analyze different RTAs and obtain different results. We thus propose to lead our own analysis.

### 3 Trade Flows Data and Bilateral Omitted Variables

The heterogeneity of results finds in our meta-analysis can have two origins: the data used and the controls that varies from one study to another. We thus investigate these two points in that section.

#### 3.1 Empirical strategy

The first contribution to this section is to introduce country-pair fixed effects as recommended by the literature but rarely used to analyse African trade. These bilateral fixed effects force the identification to come 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. For instance, 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:

$$X_{odt} = \exp [\alpha + f_{ot} + f_{dt} + f_{od} + \phi_{odt}] + \epsilon_{odt}, \quad (4)$$

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  $\phi_{odt}$  takes into account African and other RTAs that can explain trade:

$$\phi_{odt} = \psi.RTA_{odt}^{African} + \lambda.RTA_{odt}^{Other}, \quad (5)$$

where  $RTA_{odt}^{African}$  refers to a vector of dummies taking one the year when an African RTA is enforced (see Table 1, Column 2)<sup>5</sup>. We consider the seven RTAs surveyed until now, namely COMESA, EAC, WAEMU, CEMAC, SADC, SACU and ECOWAS.  $RTA_{odt}^{Other}$  takes one for all other RTAs (such as the 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).<sup>6</sup>

## 3.2 Data

Authors that analyze the international trade of African countries rarely discuss the choice of their databases. This absence of discussion is surprising because different databases exist and have pros and cons that can influence the estimates of RTAs. The gravity equations used in our meta-analysis are estimated with three different databases that are COMTRADE from the United Nations, DOTS from the IMF, and BACI from the CEPII.<sup>7</sup> 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).<sup>8</sup> For instance, trade flows are sometimes reported by only one partner. Another case is when the volume of flows differs depending on 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 others are not.

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<sup>5</sup>For ECOWAS, EAC and WAEMU we take the year of the implementation of FTAs (i.e. 1975, 2000, 1994)

<sup>6</sup><https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html>

<sup>7</sup>Some other databases 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.

<sup>8</sup>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.

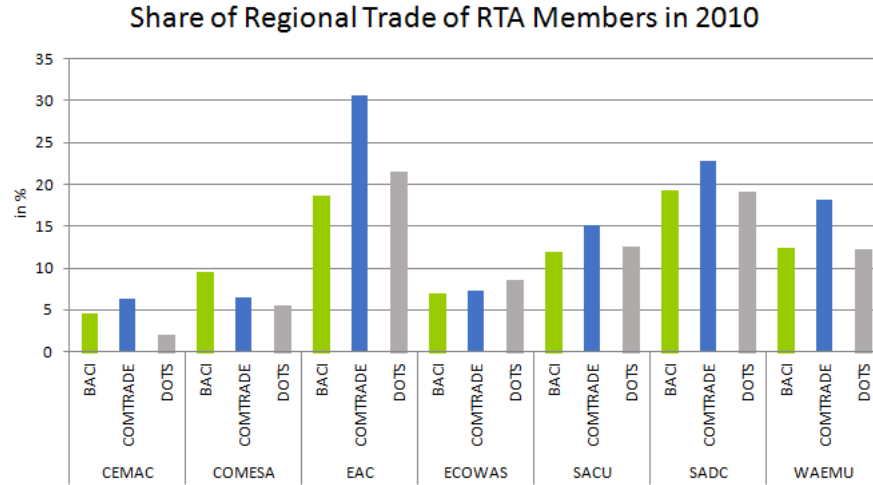
COMTRADE provides data that are directly reported by each country to the United Nations Statistical Division. There is no reconciliation between importers and exporters. In DOTS some corrections are done for non-reporting and slow-reporting countries. BACI reconciles more systematically the declarations 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 3.2). 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 between African countries may be less reliable because both the exporter and the importer may face difficulty to correctly collect data.<sup>9</sup> This may explain why BACI and DOTS provide a smaller share of regional trade than COMTRADE.

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<sup>9</sup>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.

Figure 3: 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 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 differs 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.<sup>10</sup> The time period for these three databases is thus from 1962 to 2014.

### 3.3 Results

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 an-

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<sup>10</sup>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.



other, 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.

Table 3: RTAs in Africa

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

Notes: <sup>a, b</sup> 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.

## 4 Why are RTAs in Africa Overestimated?

### 4.1 Past 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 in order to do not overestimate the effects of RTAs. We thus add two dummy variables that vary over time namely a dummy for the GATT/WTO membership and a dummy for bilateral military conflicts. The GATT/WTO membership may have reduced the cost of international trade relatively to regional trade leading to underestimate the effect of RTA. On the opposite, the end (or start) of bilateral conflicts can stimulate (deteriorate) regional trade relatively to the rest-of-the world leading to biased the coefficient of RTA when this variable on conflicts is omitted.

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 signature of the agreements. Regarding these findings, it seems surprising that the many studies on African RTAs find a so strong effect since these agreements have often taken years to be implemented and are even known to be imperfectly applied.<sup>11</sup> It is also possible that the dummies built to proxy the most recent RTAs simply capture past RTAs. 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 current RTAs. In that case, the lack of control concerning these past agreements, can biased upward the current RTAs. To our knowledge, there is no study that have taken into account the history of RTAs in Africa.

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

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

$RTA_{odt}^{African}$  and  $RTA_{odt}^{Other}$  have already been defined previously.  $PastRTA_{odt}^{African}$

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<sup>11</sup>It is obviously possible that the simple signature of these agreement have exhibited anticipatory effects (McLaren, 1997; and Baier and Bergstrand, 2007) due to firms that have anticipated a better market access.

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), namely UDAO, UDEAO, CEAO, UDEAC, SADCC and EAC (1967-1977). All these dummies concerning RTAs are computed from Mario Larch's Regional Trade Agreements Database (Egger and Larch, 2008).<sup>12</sup> Data on GATT and WTO membership is taken from the WTO.<sup>13</sup> 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 Appendix B, for results based on COMTRADE and BACI) with the PPML estimator. Column 1 of Table (4) is the baseline presented in the previous section (Column 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  $\lambda$  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 some problems remain.

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<sup>12</sup><https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html>

<sup>13</sup>[https://www.wto.org/english/thewto\\_e/whatis\\_e/tif\\_e/org6\\_e.htm](https://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm)

Table 4: RTAs in Africa

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

Notes: <sup>a, b</sup> 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 dependant 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 thougher 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 ag-

gregated over 26 sectors of activity<sup>14</sup> 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:

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

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

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

where  $\phi_{odt}$  is given by Equation (6).

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<sup>14</sup>See <https://worldmrio.com/eora26/> for further details about sectoral aggregation and the structure of EORA26

Table 5: RTAs in Africa

Control	Border	Random Trend	+WTO + War
<i>EAC</i>	0.274 (0.217)	-0.228 (0.147)	-0.196 (0.116)
<i>COMESA</i>	0.455 <sup>b</sup> (0.212)	0.208 <sup>a</sup> (0.079)	0.223 <sup>a</sup> (0.073)
<i>WAEMU</i>	0.344 (0.332)	-0.256 (0.148)	-0.249 (0.153)
<i>ECOWAS</i>	0.521 (0.555)	0.055 (0.263)	0.124 (0.253)
<i>CEMAC</i>	0.079 (0.275)	-0.410 (0.239)	-0.411 (0.250)
<i>SADC</i>	0.109 (0.155)	0.090 (0.109)	0.026 (0.092)
<i>RTA<sup>Other</sup></i>	0.164 (0.095)	0.042 <sup>b</sup> (0.019)	0.056 <sup>a</sup> (0.020)
OBS	384953	418697	380837
R <sup>2</sup>	0.982	0.997	0.9973

Notes: <sup>a, b</sup> denote significance at the 1 and 5 percent level respectively. Robust clustered standard errors are reported under each coefficient. Regressions in Column 1 are done with the PPML estimator and with importer, exporter and country-pair fixed effects (  $f_o$  ,  $f_d$  ,  $f_{od}$  ). Regressions in Column 2 and 3 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 3. International trade flows comes from the DOTS and intranational flows from EORA. The time period for all these regressions is 1990-2015.

Table (5) shows that the simple introduction of the border and of internal flows is enough to made ECOWAS and SADC insignificant. Only COMESA remains significant with a coefficient of 0.455. The Random Trend model reduces this coefficient around 0.2.

## 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  $\lambda$ . 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  $\lambda$  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  $\lambda$ .

To analyse 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  $\lambda$  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  $\lambda$  with the PPML estimator presented in Table (4, Column 1). The choice of the PPML estimator, while not perfect and raising issues when nonreported data are replaced by zeros<sup>15</sup>, 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, our preferred estimation is provided by Table (5, Column 2). We report below these estimation of  $\lambda$  when significant (written n.s. otherwise).

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<sup>15</sup>Martin (2021) shows that many estimators, including the PPML estimator, are biased because dependent variables are limited-dependent and because nonreported data are frequently replaced by zeros.

Table 6: RTAs in Africa

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

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 analyse the general equilibrium effect of  $\lambda$  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 Appendix C, simulations using the estimates of Column 1 and 2.

## 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:

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

where  $\sigma$  is the elasticity of substitution between varieties ( $\sigma > 1$ ),  $\phi_{od}$  an unversed measure of trade costs  $\tau_{od}$  ( $\phi_{od} = \tau_{od}^{1-\sigma}$  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<sup>16</sup>) 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 buyers' 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:

$$\Pi_o^{1-\sigma} \equiv \sum_{d=1}^n (\tau_{od}/P_d)^{1-\sigma} Y_d \quad (10)$$

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

$$P_d^{1-\sigma} \equiv \sum_{o=1}^n (\tau_{od}/\Pi_o)^{1-\sigma} Y_o \quad (11)$$

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  $\phi_{od}$  in the numerator of (9), from  $\phi_{od}$  to  $\phi_{od}^c$ , 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  $\psi$ , we can write the *direct* effect of the enforcement of RTA on bilateral trade flows in a very simple form:

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<sup>16</sup>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 utilisation of these trade preferences in Africa.

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

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.<sup>17</sup> 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<sup>18</sup>:

$$PIE_{od} \equiv \frac{\Pi_o P_d}{\Pi_o^c P_d^c} \exp[\lambda(RTA(1)_{od} - RTA(0)_{od})]. \quad (13)$$

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  $\hat{\lambda}$  and presented in Table (6), to compute  $\phi_{od}$  such as  $\phi_{od} \equiv \exp[\hat{\lambda}RTA_{odt}]$ . Using this measure of  $\phi_{od}$  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  $\Pi_o$  and  $P_d$ .

Then using these measures of  $\phi_{od}$ , we get from Equation (12) the counterfactual trade costs  $\phi_{od}^c$ , i.e.  $\phi_{od}^c \equiv \phi_{od} \exp[\hat{\psi}(RTA(1)_{od} - RTA(0)_{od})]$ . Using again the contraction mapping with  $\phi_{od}^c$  and with the same expenditures  $Y_o$  and  $Y_d$  provides the counterfactual multilateral resistances  $\Pi_o^c$  and  $P_d^c$ . All these findings give the *PIE* of RTAs presented in Equation (13).

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<sup>17</sup>The literature usually work with a “hat”, a notation here preserved to notify the predicted value of coefficients.

<sup>18</sup>Head and Mayer (2014) call this effect the Modular Trade Impact in reference to Anderson (2011).

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:

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

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:

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

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:

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

Using the direct effects calculated earlier, with  $Y_o$  approximated by GDPs, and the trade share  $\pi_{od}$  of each country  $o$ , gives from (15) a system of equations defining  $\dot{Y}_o$ , which once inserting in the trade share expenditure (14)<sup>19</sup>, gives the General Trade Equilibrium Impact (GETI) of trade shock:  $\dot{\pi}_{od} \dot{Y}_d$ . We also compute the welfare gains of RTAs under this quantitative exercise,

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<sup>19</sup>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).

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.<sup>20</sup>

## 6 Results

### 6.1 General Equilibrium Effects

Table (7) presents the PIE and GETI effects for the COMESA with the baseline estimate of  $\lambda$  (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  $\lambda$  are high (“baseline” and “meta” line) but even with the smallest value of  $\lambda$  (“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.

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<sup>20</sup>We choose the 2006’s table as benchmark year and the Uruguay as a reference since this country shares characteristics with some African countries in terms of size and in terms of trade agreements. Readers have to keep in mind that with a General Equilibrium model, the solution is independent of the normalization by the reference country. However to avoid any doubt about that, we have checked that changing reference country does not modify our results. With Perou, Paraguay and Vietnam which are more close to Subsaharian Africa in terms of GDP per capita, findings are still the same. We have also analysed different benchmark year (2010 and 2000). Results are similar.

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, see Figure 3.2), 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  $\lambda$  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  $\lambda$  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.

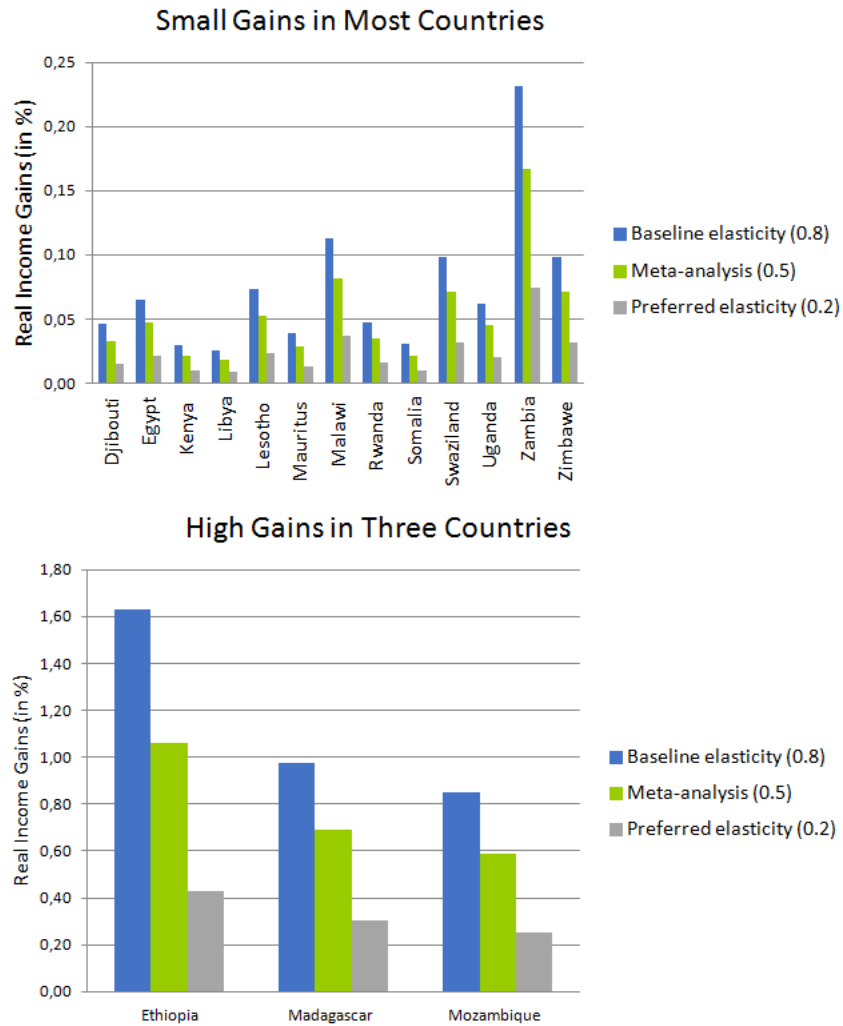
To conclude on these results, the three scenario provides a similar conclusion: the trade creation of the COMESA has been strong, but the trade diversion has reduced the total gains. The real income gains (see Figure 6.1) of COMESA are very low for most countries (i.e. below 0.25%). Only three countries have a clear benefit with 1.6% of income growth in Ethiopia, 1% in Madagascar and 0.8% in Mozambique in the most favourable 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 4: 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 insignificant. 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 analyse 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 imple-



mentation 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 Appendix A: Studies of the meta-analysis

The meta-analysis is based on 22 articles among which 16 have already be presented and are referenced in the bibliography: Carrere (2004, 2013), Cernat (2001), Cissokho et al. (2012), Djoumessi and Bala (2017), Elbadawi (1997), Guepie and Schlick (2019), Inancli and Addi (2019), Kaminchia (2019), MacPhee and Sattayanuwat (2014), Mayer and Thoenig (2016), Magee (2008), Musila (2005), Ngepah and Udeagha (2018), Nguyen (2019), Subramanian and Tamirisa (2001).

Six articles have not been presented in the text:

1. Agbodji, A. E. (2007). Intégration et échanges commerciaux intra sous-régionaux : le cas de l’UEMOA. *Revue africaine de l’intégration*, 1(1), 161-188.
2. Buigut, S. (2016). Trade effects of the East African Community Customs Union: hype versus reality. *South African Journal of Economics*, 84(3), 422-439.
3. Deme, M., & Ndrianasy, E. R. (2017). Trade-creation and trade-diversion effects of regional trade arrangements: low-income countries. *Applied Economics*, 49(22), 2188-2202.
4. Longo, R., & Sekkat, K. (2004). Economic obstacles to expanding intra-African trade. *World development*, 32(8), 1309-1321.
5. Rojid, S. (2006). COMESA trade potential: a gravity approach. *Applied Economics Letters*, 13(14), 947-951.
6. Umulisa, Y. (2020). Estimation of the East African Community’s trade benefits from promoting intra-regional trade. *African Development Review*, 32(1), 55-66.

## 9 Appendix A: Fixed Effect model of the Meta-analysis

Table 8: : 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

## 10 Appendix B: PPML and controls under different databases

Table 9: RTAs in Africa

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

Notes: <sup>a b c</sup> 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. See the list in Appendix) but are not reported here to make the table readable.

## 11 Appendix C: Simulations for ECOWAS and SADC

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

Table 10: 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
Cabo 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 11: SADC

Iso_o		PIE			GETI		
		Intra	Extra	All	Intra	Extra	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
Mauritius	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

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