Trade, Shocks Transmission, and Monetary Policy in a Regional Trade Agreement

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Abstract

In this paper, we first document that climatic or political shocks in an origin country (or exporting country) affect inflation in the destination country (its importing partner) through trade among African countries. Second, we demonstrate that existing Regional Trade Agreements (RTAs) in Africa have significantly increased trade by 62 to 77 percent from 1995 to 2019. These figures are lower than most estimates in the literature. We address several issues related to estimating the effects of RTAs, namely the selection bias due to many zeros in trade data, their staggered adoption feature, and their heterogeneous effects across regions. To deal with these issues, we apply a structural gravity model, a Pseudo Poisson Maximum Likelihood (PPML) method, and a state-of-the-art event study. Third, after showing evidence that trade transmits shocks and that RTAs significantly increase trade, we develop a theoretical model to discuss the broader implications of regional trade agreements for monetary policy. We use the model to explore how the African Continental Free Trade Agreement (AfCFTA), adopted in 2021, could affect countries' inflation and its implications for their monetary policy.

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1 Introduction

Trade by transmitting shocks across countries can alter a country's monetary policy's ability to reach its goals (Cwik et al., 2011). However, transmission of shocks through trade is less documented among African countries, this might be due to the fact that intra-African trade is low compared to other regions in the world: 18% in 2020, against 68% in Europe and 58% in Asia (United-Nations, 2022). However, with the increase in the number of regional trade agreements (RTA) in Africa, especially with the recent African Continental Free Trade Area (AfCFTA) in 2021, the largest RTA covering all African countries, intra-trade in Africa is projected to increase significantly (Mal-

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iszewska et al., 2020; ElGanainy et al., 2023; World Trade Organization, 2023) [1].

In addition, given that African countries are subjected and more vulnerable to many shocks, namely political and climatic shocks compared to other regions in the world (Hassler and Krusell, 2012; IPCC, 2022, 2023), understanding the effect of trade in shock transmission across African countries is detrimental for policymakers, especially for Central Banks monetary policy since the role of monetary policy, in general, is about achieving price stability and managing economic fluctuations. Indeed, one main characteristic of African countries is that they are less industrialized and produce mainly raw materials, therefore climate change by affecting their production could affect their exports and therefore prices with their African trading partners.

In this paper, we first document that climatic or political shocks in an origin country(or exporting country) affect inflation in the destination country (its importing partner) among African nations. Specifically, a 1% decrease in imports due to temperature increases or violent conflict in the origin country raises inflation in the destination country by 0.4 to 0.58%. To do so, we used an instrumental variable (IV) strategy, focusing on how shocks in the origin country affect inflation in the destination country through trade. Imports from the origin country are endogenous when directly regressed on inflation in the destination country. For example, increasing domestic demand (e.g., increased public spending) or a reduction in domestic production in the destination country can simultaneously affect both inflation in the destination country and imports from the origin country. Therefore, we used temperature and conflict-related deaths in the origin country as instruments to isolate the trade-induced inflation effect. The validity of these instruments is discussed in Section 2.3.

Second, we demonstrate that existing Regional Trade Agreements (RTAs) in Africa have significantly increased trade by 62 to 77 percent from 1995 to 2019. These results are robust across various estimation strategies addressing common issues such as selection bias due to zero trade data, heterogeneous effects across time and space, and the staggered adoption of RTAs. Previous estimates of the RTA impact on trade in Africa vary widely across studies, likely due to differences in estimation strategies and the specific RTAs considered. Our focus is on the average overall effect of RTAs on trade in Africa, which could be important in anticipating the potential impact of the recent African Continental Free Trade Area (AfCFTA) covering all African countries. To obtain our results, we employ three estimation techniques. We start with the standard structural gravity model by Anderson and Van Wincoop (2003), which, by excluding zero trade data, may be biased due to selection issues arising from this exclusion. To address this, we complement our analysis with Pseudo Poisson Maximum Likelihood (PPML) estimation, which incorporates all sample values, including zeros. Although widely used in the literature, these two previous methods have limitations in estimating the effects of staggered policies such as RTAs. Additionally, they may be biased if the effects of RTAs are heterogeneous over time and space, which is very likely to be the case. To overcome these limitations, we finally use an event study methodology robust to heterogeneous treatment effects, as proposed by Callaway and Sant'Anna (2021). Importantly, the estimates from these three methods are very close to each other: 77 percent for the structural gravity method, 63 percent for the PPML, and 62 percent for

[1](Maliszewska et al., 2020) states that trade could increase by 52% in 2035 and more than double after full implementation of AfCFTA.

the event study. Furthermore, to our knowledge, this study is the first to estimate the timing of the RTA effect in Africa, finding that it takes, on average, up to eight years for an RTA to significantly impact trade after its implementation.

Thirdly, after showing evidence of the fact that trade transmits shocks across African countries and that RTAs increase trade significantly, we take a step back and develop a theoretical model to discuss more generally the implications of regional trade agreements for monetary policy. In doing so, we build an international trade model a la Eaton and Kortum (2002) augmented with a central bank to quantify the effect of some simulated increase in trade on shocks transmission across countries.

Related Literature

The current paper is related to three strands of literature. First, it is related to the literature on the transmission of shocks through trade across countries (Corsetti et al., 2008; di Giovanni and Levchenko, 2009; Enders and Müller, 2009; Caselli et al., 2020; Kejžar et al., 2022; Baqaee and Farhi, 2024; Benguria et al., 2024; Camara et al., 2024). Enders and Müller (2009) and Corsetti et al. (2008) provide empirical evidence on how international trade can act as a conduit for transmitting economic disturbances across borders. More recently, Baqaee and Farhi (2024), Benguria et al. (2024), and Camara et al. (2024) have explored the network effects and sectoral spillovers that amplify shock transmissions in global trade networks. Further, Kpodar and Imam (2016) investigate the effects of Regional Trade Agreements (RTAs) on growth volatility. Analyzing data from 172 countries over the period 1978-2012, they find that RTAs significantly reduce growth volatility. Their study suggests that countries are more likely to join RTAs when they are exposed to higher growth shocks and have potential partners with stable economic growth.

Despite this rich literature, studies on shock transmission through intra-trade in Africa are scarce, with some exceptions including Ncube et al. (2014). This scarcity might be due to two reasons. First, the low level of intra-trade in Africa, around 18% in 2020, which may have a negligible effect on shock transmission. Second, the a lack of data to identify shocks that could be transmitted through trade. However, with the recent African Continental Free Trade Agreement (AfCFTA), intra-trade in Africa is likely to increase, making the question of how trade transmits shocks in Africa a timely topic. This paper is unique because it is the first to use data on temperature and political conflict to provide evidence of shock transmission through trade among African countries.

Somanathan et al. (2021) and Burke et al. (2015) explore the impact of temperature variations on productivity and labor supply, demonstrating a non-linear relationship between temperatures and macroeconomic productivity. These studies suggest that climatic shocks in one country can significantly affect its trade partners through changes in productivity and export capacities. In addition to climatic shocks, we study the effect of political shocks in an origin country on inflation in the destination country through trade.

Second, this paper is related to the extensive literature on the effectiveness of RTAs in increasing trade (Carrere, 2006; Baldwin and Taglioni, 2007; Glick and Rose, 2016; de Soyres et al., 2021), with a focus on Africa. Previous estimates of the effect of RTAs in Africa vary widely (Geda and Yimer, 2023; Ngepah and Udeagha, 2018; MacPhee and

Sattayanuwat, 2014). This variability can be attributed to differences in methodologies and the specific RTAs or samples used. In our study, we focus on the overall effect of RTAs in Africa and address several methodological issues inherent in estimating their effects.

We begin by estimating a structural gravity model as developed by Anderson and Van Wincoop (2003). This model accounts for the inward and outward multilateral resistance (MTR), taking into consideration that trade between two countries is influenced by the relative trade costs of all other trading partners. To capture this, we include importer and exporter fixed effects, which correct for the bias of omitted variables and reflect that changes in trade costs on one bilateral route can affect trade flows on other routes due to relative prices effects. Additionally, we include pair dummies to eliminate unobserved time-invariant factors between countries (such as deep-seated historical trust or distrust, informal trade networks that are not documented, and unofficial influence of diaspora communities on trade patterns), following Baldwin and Taglioni (2007). This methodology allows us to isolate the variation in the effects of RTAs over time. Using this empirical specification, we find that the effect of RTAs in Africa, while significant, is lower than most previous estimates. For instance, Ngepah and Udeagha (2018) report effects generally exceeding 100%, whereas our estimates range between 62% and 77%. Unlike Ngepah and Udeagha (2018), who focused on the specific effect of each RTA individually in Africa, we estimate the overall effects of RTAs on trade. Additionally, to account for selection bias due to zeros in trade data, we use a PPML estimation. Our OLS estimate is 77%, but accounting for selection bias with PPML reduces this estimate to 63%.

Furthermore, MacPhee and Sattayanuwat (2014) found that the intra-RTA effect for ECOWAS is 128%, while the effect for SADC is 208%. Conversely, the effect for CEMAC was not significant, highlighting the heterogeneity among different RTAs in Africa. Given this evident heterogeneity, to the best of our knowledge, our study is the first to document the overall effect of RTAs on African trade, considering their heterogeneous effects by applying the event study methodology developed by Callaway and Sant'Anna (2021). Using this approach, we find an estimated effect of 62%, which is 1% lower than the PPML estimate.

Third, it is related to how RTAs transmit shocks across countries and their implications for monetary policy (Silveira, 2015; Corsetti et al., 2007, 2005). Eaton and Kortum (2012) discusses how the popular Ricardian model can be used to address many economic issues, including the welfare effects of trade deficits, wage responses to decreases in trade barriers, and responses to technological changes. Eaton and Kortum (2002) develops a Ricardian model that incorporates technology and geography in trade among countries. This model is used to quantify gains from trade and from tariff reductions. They find that all countries gain from free trade, with smaller countries gaining more than larger ones. They also calculate the role of trade in spreading technology across countries.

Caliendo and Parro (2015) estimate the trade and welfare effects of NAFTA from tariff changes using a Ricardian model similar to Eaton and Kortum (2002). Importantly, they study how gains from tariff reduction spread across sectors and find that tariff reduction leads to more specialization, especially for Mexico. They also find that, unlike Mexico and the US, Canada suffers a welfare loss.

Our model is closer to Naito (2017), who combines an Eaton and Kortum (2002) model of trade with an Acemoglu and Ventura (2002) AK model to explain the implications of trade on economic growth. Since we are primarily interested in the effects on inflation and monetary policy transmission, we augment the model with a Central Bank. We are also interested in quantifying how AfCFTA could affect shocks transmission across African countries.

The remainder of this paper is structured as follows. In Section 2, we provide empirical evidence of the transmission of climatic and political shocks across African countries through trade, along with evidence of the effectiveness of RTAs in increasing trade in Africa. Section 3 presents the theoretical model. Section 4 discusses the results of the theoretical model. Finally, Section 5 concludes the paper.

2 Empirical investigation

This section aims to provide empirical evidence of shock transmission through trade and to assess the effectiveness of Regional Trade Agreements (RTAs) in Africa. We begin by presenting the data, followed by an analysis of how climatic and political shocks in an origin country affect inflation in its trading partner, the destination country. Subsequently, we examine the effectiveness of RTAs in enhancing trade within Africa.

2.1 Data presentation

The data for the analysis of shocks transmission through trade comes from two principal sources. On the one hand, to capture climatic shocks we rely on the *PRIO-GRID* framework, a standardized grid of 0.5 x 0.5 decimal degrees covering the globe Tollefsen et al. (2012). We consider the grid-level average annual temperature, precipitation level and grid-level population (cite individual sources). Temperature and precipitation are aggregated at the country level by considering the weighted mean across all grid cells falling inside its boundaries. Each grid is weighted by the share of national population falling inside its area. On the other hand, to capture socio-political shocks, we rely on the Social Conflict Analysis Database (SCAD) from Idean et al. (2012). We use the number of fatalities from protests, riots, strikes, political and military conflicts, and other social disturbances. We aggregate this event-level information by computing the total number of fatalities at the country-year level. We exclude events that span multiple years as their occurrence in one year might be endogenized by agents in the following years.

The data for the gravity regression come from the data set **Gravity** of `Centre d'études prospectives et d'informations internationales` CEPII (Conte et al., 2022). The main variable of interest is the Regional Trade Agreement (RTA). The World Trade Organization (WTO) recognizes four distinct categories of Regional Trade Agreements (RTAs): Partial Scope Agreements (PSA), Free Trade Agreements (FTA), Customs Unions (CU), and Economic Integration Agreements (EIA). PSAs usually entail the removal of import tariffs in a limited number of sectors, while FTAs generally involve the elimination of import tariffs across most sectors, with each member retaining the ability to enact their own trade policies. Customs Unions, which build upon FTAs, require member states to synchronize their external trade policies and implement a common external tariff. Economic Integration Agreements focus on the liberalization of trade in services. Some examples are Economic Community of West African States (ECOWAS) [2] (wich include West African Economic and Monetray Union (WAEMU, a CU)), Common Market for Eastern and Southern Africa (COMESA) [3], Economic and Monetary Community of Central Africa (CEMAC) [4], etc.

Table 1: Variables and their sources

Variable	**description**	**Source**
Bilateral trade data	Detailed at 2 digits classification level	WTO Stats
RTA	Dummy equal to 1 if origin and destination countries are engaged in a regional trade agreement of any type within the given year	CEPII(from WTO)
distcap	bilateral distance between capitals, measured in km	CEPII
contiguty	Dummy equal to 1 if countries are contiguous, bilateral	CEPII
comlang_off	Dummy equal to 1 if countries share common official or primary language, bilateral	CEPII
GDP_o	GDP of the origin country, in current thousands US	CEPII (from WDI)
GDP_d	GDP of the destination country, in current thousands US	CEPII (from WDI)
Temperature	Average annual temperature in degrees	PRIO-GRID
Precipitation	Total annual precipitation in millimeter	PRIO-GRID
NDeaths	Total annual deaths in social conflicts	SCAD

2.2 Descriptive statistics

Our study, illustrated in Figure 1, examines the average trade share of product categories among African countries between 1996 and 2016. We employed a detailed product classification at the two-digit level Word Custom Organization's website. To compute the share, we aggregated the total trade volume for each year across all products and calculated the proportion of each product's trade volume to the total. Our findings show that *mineral products*, comprising of oil, gas, cement, Cobalt, aluminum, uranium, and other materials, were the most commonly exchanged products among African countries, followed by *electrical equipment, base metals, and chemical products*, each accounting for approximately 9% of total trade. In contrast, the least traded products were collector's pieces, arms and munitions, and raw hides and skins, which accounted for less than 0.5% of total trade.

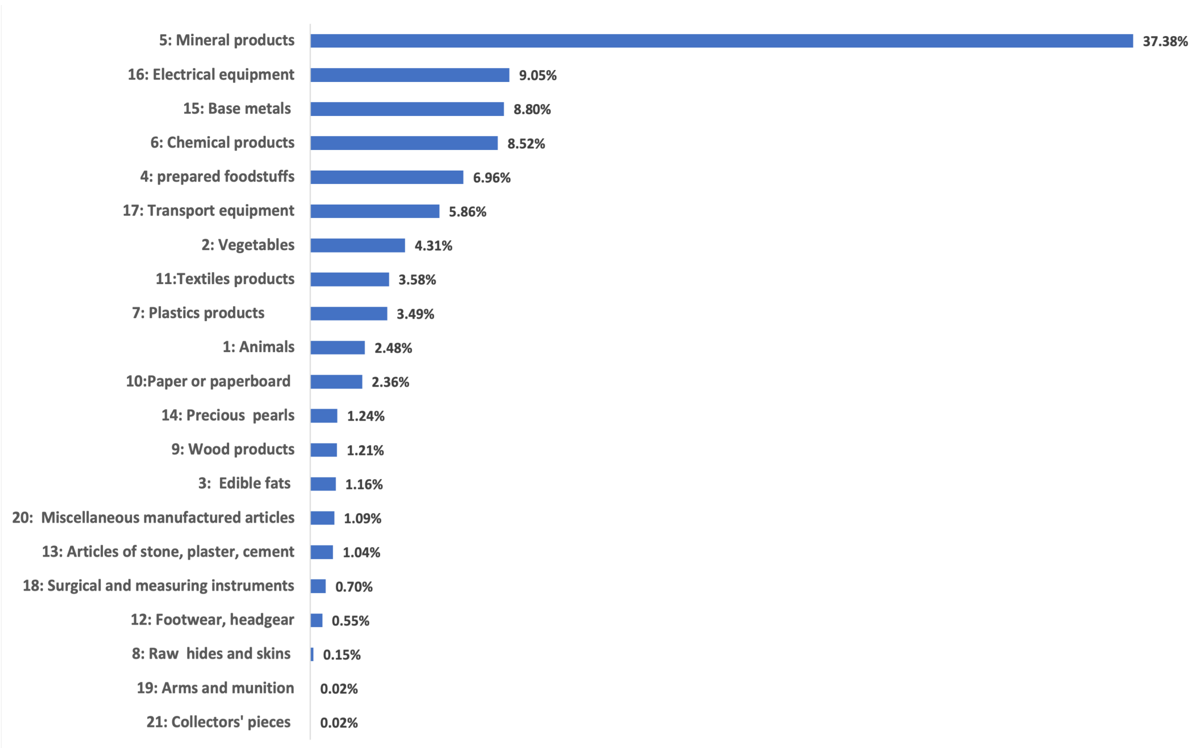
[2]It's a FTA composed of Cabo Verde; Benin; The Gambia; Ghana; Guinea; Côte d'Ivoire; Liberia; Mali; Niger; Nigeria; Guinea-Bissau; Senegal; Sierra Leone; Togo; Burkina Faso

[3]the signatories are: Angola; Burundi; Comoros; Democratic Republic of the Congo; Ethiopia; Eritrea; Kenya; Lesotho; Malawi; Mauritius; Rwanda; Seychelles; Zimbabwe; Sudan; Eswatini; Uganda; Egypt; Tanzania; Zambia

[4]Cameroon; Central African Republic; Chad; Congo; Equatorial Guinea; Gabon

However, it is essential to note that there was a substantial variance in trade volume across different products. For example, animals had the least variation with a standard deviation of 279,816, while the standard deviation of transport equipment was 554 times higher. The most commonly traded products, *mineral products*, had a standard deviation approximately 94 times higher than animals. This heteroskedasticity in the data implies that some products are significantly more volatile in terms of trade volume than others. Moreover, this heteroskedasticity is still apparent at the country pairs level, as illustrated in Figure 12.

Figure 1: Intra African trade share by product category



Notes: Average trade among African countries by product over the period 1996-2016

2.3 Trade and shock transmission across African countries

2.3.1 Empirical specification

To what extent do trade flows transmit shocks across African countries? To answer this question, we focus on one type of climatic shock, namely temperature shocks in the origin country, and ask whether inflation in the destination country is affected. We rely on the local average treatment effect (LATE) interpretation of the instrumental variable estimand put forward in Angrist and Imbens (1994); Angrist et al. (1996). Indeed, for a given instrument Z, a treatment X, and an outcome variable Y, the IV-estimator identifies under suitable conditions the change in the outcome variable due to changes in the treatment X for those units who respond to the instrument Z. In our setup, a unit of observation is a pair of origin-destination countries (o, d), the instrument is the temperature in the origin country (z_{ot}) and the treatment variable is the trade flow from country o to country d (x_{dot}). One of the conditions underlying the IV-regression LATE interpretation is for the instrument to actually induce changes in the treatment variable. [5] Jones and Olken (2010) show that higher temperatures in poor countries have a negative effect on the growth of their exports to the US and to the world. Moreover, the decrease is experienced not only in agricultural goods but also in light manufacturing. For temperature shocks to be a valid instrument in our setup, they might first induce changes in trade flows across African countries. We show below, by estimating equation 2, that for a given pair of trading countries (o, d), an increase in temperature in the origin country o reduces trade flow from o to d. The second condition, which is referred to as the exclusion restriction, states that the instrument should only influence the outcome variable through the treatment variable. Thus in our case, a temperature shock in the origin country should only affect inflation in the destination country through its effect on the supply of goods to the destination country. This would be violated for example, if temperature increases systematically simultaneously in the origin and destination country. In this case, both partners would experience a negative supply shock and the estimated IV-effect would conflate inflationary pressures originating both inside and outside the destination country. We control for this possibility by also adding the temperature in the destination country in equation 1 which links inflation in the destination country to the trade flow between origin and destination countries. We implement the IV procedure described above by estimating the following equations:

$$y^d_{dt} = a_{do} + \lambda_t + \alpha x_{dot} + \varepsilon_{dot} \tag{1}$$

$$x_{dot} = b_{do} + \gamma_t + \beta z_{ot} + u_{dot} \tag{2}$$

Where for each period t, y^d_{dt} denotes inflation in the destination country d, x_{dot} imports of country d from country o , a_{do} a pair destination $\times$ origin fixed effect , λ_t a time fixed effect, and ε_{dot} an error term capturing other factors influencing inflation aside from international trade. We assume that trade flows are potentially correlated with these latter factors: $cov(x_{dot}, \varepsilon_{dot}) \neq 0$. For example, an increase in public spending in country d might simultaneously increase inflation and imports in machinery. To deal with this endogeneity issue, we use alternatively climatic and socio-political shocks in exporter country o (denoted by z_{ot}) as an instrument to import of d from o.

On the one hand to control for the unbalanced panel nature of the available data on trade, we estimate the above regressions using two samples as described in table 2. In sample 1, we consider all the pairs of Origin-destinations for which some data on trade is available between 2001 and 2015, while in Sample 2, we consider only pairs that have trade observations for more than half the period 2001-2015. Although trade flows data are available up to 2019, information on temperature from the PRIO-GRID is only available up to 2014. On the other hand to control for the heteroskedasticity of trade flows across different pairs of countries (*Give evidence of heteroskedasticity and justify the need for a GLS regression as in Jones and Olken*), we estimate the regressions using

[5] also called endogenous variable

both OLS and Feasible Generalized Least Squares as in Jones and Olken (2010) [6].
In a given year, for each pair, we use as a measure of climatic shocks for trade flows the temperature in the previous year in the origin country. Socio-political shocks in the origin country are captured by a dummy variable equal to 1 if the number of deaths in socio-political conflicts is in the last quartile of the sample (precise the threshold absolute value of deaths).
Table 2 presents descriptive statistics of variables used in the estimations. Sample 1 and 2 contain respectively 1712 and 1160 pairs of countries. Sample have 51 origin countries and 38 destination countries while in sample 2 have the same set of origin countries but with 3 less destination countries (Gambia, Guinea-Bissau and Sierra Leone).[7]

Table 2: Descriptive Statistics

Sample 1

	count	min	p25	p50	mean	p75	max
bilateral imports (million USD)	15941	1.9e-09	0.024	0.34	35.8	5.06	5132.5
temperature deviation in origin	14971	-2.00	-0.12	0.084	0.089	0.31	3.47
#deaths in social conflict in origin	15941	0	0	2	152.6	26	8791
#deaths in social conflict in origin if $\#deaths > 0$	9180	1	4	18	265.1	152	8791
#deaths Above Q3	15249	0	0	0	0.15	0	1
pairwise SD of log(Imports)	15941	0.0011	0.92	1.58	1.68	2.27	6.65
pairwise SD of temperatures in origin	15941	0.0076	0.26	0.33	0.39	0.46	2.68
inflation in destination	15673	-2.20	2.27	4.91	5.92	8.50	32.9
RTA	15941	0	0	0	0.23	0	1
Observations	15941						

Sample 2

	count	min	p25	p50	mean	p75	max
bilateral imports (million USD)	13716	1.9e-09	0.044	0.60	41.0	6.97	5132.5
temperature deviation in origin	12916	-2.00	-0.12	0.084	0.088	0.31	3.47
#deaths in social conflict in origin	13716	0	0	2	156.0	30	8791
#deaths in social conflict in origin if $\#deaths > 0$	8030	1	4	18	266.5	152	8791
#deaths Above Q3	13181	0	0	0	0.15	0	1
pairwise SD of log(Imports)	13716	0.13	0.90	1.51	1.62	2.21	6.18
pairwise SD of temperatures in origin	13716	0.083	0.26	0.33	0.39	0.45	2.06
Inflation in destination	13491	-2.20	2.18	4.77	5.89	8.68	32.9
RTA	13716	0	0	0	0.25	0	1
Observations	13716						

Notes:

[6] Residuals from the OLS regressions are used to estimate pair-specific variances which are used as weights in a second OLS regression

[7] Sample 1
Origins: AGO BDI BEN BFA BWA CAF CIV CMR COD COG COM CPV DJI DZA EGY ETH GAB GHA GIN GMB GNB GNQ KEN LBR LBY LSO MAR MDG MLI MOZ MRT MUS MWI NAM NER NGA RWA SDN SEN SLE STP SWZ SYC TCD TGO TUN TZA UGA ZAF ZMB ZWE
Destinations: BDI BEN BFA BWA CAF CIV CMR CPV EGY GAB GHA GIN GMB GNB KEN LSO MAR MDG MLI MOZ MRT MUS MWI NAM NER NGA RWA SEN SLE SWZ TCD TGO TUN TZA UGA ZAF ZMB ZWE
Sample 2
Origins: AGO BDI BEN BFA BWA CAF CIV CMR COD COG COM CPV DJI DZA EGY ETH GAB GHA GIN GMB GNB GNQ KEN LBR LBY LSO MAR MDG MLI MOZ MRT MUS MWI NAM NER NGA RWA SDN SEN SLE STP SWZ SYC TCD TGO TUN TZA UGA ZAF ZMB ZWE

2.3.2 Results

We begin by answering the question of whether the instrumental variables we consider do induce variations in trade flows across African countries. Results for the first-step regression are given in table 3. Overall, we find a significant negative impact of higher temperatures and deaths in social conflicts in the origin country on import flows to the destination country. The effect of temperature appears to be more robust both across specifications and to sample selection than the effect of deaths in social conflict. Columns 1 to 4 gives presents estimation realized on sample 1 while columns 5 to 8 presents the same estimation run on sample 2.

Focusing on OLS regressions, one degree increase on the temperature of the origin country induce a 12% to 18% reduction of imports to destination countries depending on whether one uses sample 1 or sample 2. A correction for heteroskedasticity using FGLS brings the estimates across both sample more in line, with one degree increase in origin country temperature leading to a 9 to 11% decrease in trade flows. These estimated effects are robust to the inclusion of temperatures in the destination country, supporting the fact that they are driven by a spatial correlation in temperatures. Regarding the effect of deaths in social conflicts in the origin country, the results point to a decrease in imports as social conflicts grow more violent.

At the bottom of Table 3, F-statistics across all regressions range from 7 to 14. This may suggest that our instruments are weakly correlated with trade flows as they are not likely to be the main determinants of trade flows variations across African countries.

Destinations: BDI BEN BFA BWA CAF CIV CMR CPV EGY GAB GHA GIN KEN LSO MAR MDG MLI MOZ MRT MUS MWI NAM NER NGA RWA SEN SWZ TCD TGO TUN TZA UGA ZAF ZMB ZWE

Table 3: First-step regression: shock-induced variations in trade flows (Two-digits data)

	$log(Import_{dot})$							
	Sample 1				Sample 2			
	OLS		FGLS		OLS		FGLS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Temperature_{ot-1}$	-0.125***	-0.124***	-0.0842***	-0.0861***	-0.185***	-0.184***	-0.107***	-0.109***
	(0.0435)	(0.0435)	(0.0212)	(0.0215)	(0.0475)	(0.0475)	(0.0238)	(0.0240)
$NDeaths - AboveQ3_{ot}$	-0.181***	-0.180***	-0.0909***	-0.0924***	-0.125*	-0.124*	-0.0663**	-0.0694**
	(0.0636)	(0.0636)	(0.0256)	(0.0257)	(0.0667)	(0.0669)	(0.0277)	(0.0280)
$Temperature_{dt-1}$		0.0273		0.0111		0.0399		0.0216
		(0.0492)		(0.0187)		(0.0534)		(0.0203)
$NDeaths - AboveQ3_{dt}$		0.0364		-0.0202		0.0659		-0.0156
		(0.0582)		(0.0224)		(0.0608)		(0.0238)
Constant	12.69***	12.69***	11.78***	12.58***	13.17***	13.16***	16.55***	16.57***
	(0.0104)	(0.0139)	(0.00976)	(0.00780)	(0.0110)	(0.0146)	(0.00504)	(0.00585)
Origin * destination FE	T	T	T	T	T	T	T	T
Year FE	T	T	T	T	T	T	T	T
R2	0.783	0.783	0.988	0.987	0.776	0.776	0.947	0.948
F-stat	8.318	4.406	13.87	7.398	9.507	5.407	12.62	6.748
Observations	15941	15941	15941	15941	13716	13716	13716	13716

Notes: Results based on data from 2001 to 2015. Bilateral import flows are aggregated from the product-level bilateral import data set of the WTO Standards errors are clustered at the Origin * destination level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Standards errors are clustered at the Origin * destination level.
Instruments: L_temp_agr_c_o Id0_ndeath_c_o
Dummies Cuttoffs: 75

We next turn to the analysis of possible inflationary effects of trade variations due to negative supply shocks in the origin country. Table 4 gives the results the OLS and IV estimations of the effects of trade variations on domestic inflation. OLS estimates (column 1 and 7) are of the expected negative sign but small in magnitude and non significant. A correction for heteroskecasticity using FGLS lead comparably small coefficients with the opposite sign which suggests that OLS estimates might be biased. Indeed, the relationship between inflation and importation is not unambiguous as both variables are simultaneously determined. A strong domestic demand could lead to inflationary pressures and also increase import levels. In this case both variables will be positively correlated. Conversely, a negative foreign supply shock could reduce import and create inflationary pressure in the domestic country if demand stays at its prior level. This latter channel is the one we are interested in estimating in this work. simple IV estimates (column 2, 3, 8 and 9) ,with temperature and violent social conflict as instrument, yield larger and negative coefficients. A correction for heteroskedasticity using FGLS (column 5, 6, 11 and 12), gives coefficient similar in magnitude statistically significant in most cases. We regard this similarity in terms of magnitude between the unweighted and weighted IV regressions as suggestive of possible bias being of small magnitude. These latter results imply that a 1% decrease in imports due to temperatures increases or violent social conflicts in the origin country will lead to a 0.26 to 0.58 % points increase on inflation in the destination country depending on the specification and the used sample. The preferred regression is the one controlling for the temperature and number of Deaths above the third quarter in the destination country. When using the whole sample (sample 1) between 2001 to 2015, the effect is 0.4 percent while it increases up to 0.58 percent when considering a more balanced sample (sample 2) which keeps only countries for which the data is available for at least half of the period 2001-2015.

Table 4: Inflationary effect of shock-induced trade variations

	$Inflation_{dt}$											
	Sample 1						Sample 2					
	OLS	IV-OLS		FGLS	IV-FGLS		OLS	IV-OLS		FGLS	IV-FGLS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$log(import_{dot})$	0.000326	-0.275	-0.416	0.00521	-0.259***	-0.397*	-0.0144	-0.428	-0.524	0.00751	-0.448*	-0.587*
	(0.0170)	(0.434)	(0.430)	(0.00460)	(0.0720)	(0.225)	(0.0191)	(0.429)	(0.422)	(0.00903)	(0.245)	(0.314)
$Temperature_{dt-1}$			0.802***			0.463***			0.853***			0.348***
			(0.0767)			(0.163)			(0.0846)			(0.0585)
$NDeaths - AboveQ3_{dt}$			1.016***			0.843***			1.158***			0.827***
			(0.123)			(0.0859)			(0.133)			(0.0710)
Constant	5.917***			7.086***			6.080***			3.504***		
	(0.214)			(0.0482)			(0.251)			(0.117)		
Origin * destination FE	T	T	T	T	T	T	T	T	T	T	T	T
Year FE	T	T	T	T	T	T	T	T	T	T	T	T
Observations	16072	15666	15666	16072	15666	15666	13746	13491	13491	13746	13491	13491
CD Fstat		8.361	8.256		6.407	4.040		8.961	8.854		6.238	4.403
KP Fstat		16.31	16.11		7.110	7.881		17.10	16.91		11.73	8.346
KP pval		0.000287	0.000317		0.0286	0.0194		0.000193	0.000212		0.00283	0.0154

*Notes: Results based on data from 2001 to 2015. Inflation is annually winsorized at 5%. Bilateral import flows are aggregated from the 2-digit product-level bilateral import data set of the WTO. In all IV estimations, both lagged temperature and a dummy indicating large casualties in social conflicts in the origin country are used as instruments. Standards errors are clustered at the Origin * destination level.*

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

After demonstrating the transmission of shocks through trade, we examine whether existing Regional Trade Agreements (RTAs) have increased trade in Africa. We then explore their role in shock transmission.

2.4 Effectiveness of Regional Trade Agreements in Africa

Although being predominantly reliant on raw material exports and suffering from underdeveloped infrastructure, Africa has experienced a significant increase in the number of Regional Trade Agreements (RTAs), from 6 in 1996 to 35 in 2016 (see figure 10). However, intra-African trade accounted for only 16% of total trade in Africa in 2018, which is strikingly lower compared to Europe and Asia where intra-regional trade constitutes around 60% of their total trade. Despite the proliferation of RTAs in Africa, there is a limited amount of empirical evidence on their impact on trade in the region. This poses the following simple question: do Regional Trade Agreements (RTA) increase trade in Africa?

2.4.1 Structural Gravity Regression

This section aims to investigate the relationship between trade flows and Regional Trade Agreements (RTAs) among African countries. To analyze this relationship, we employ a structural gravity model based on the influential work of Anderson and Van Wincoop (2003), which incorporates multilateral resistance terms. These terms account for the influence of relative prices among countries that participate in trade. In the model, trade between two countries is not solely determined by their bilateral factors such as economic size and geographical distance. It also takes into consideration the relative prices of other countries involved in trade, which indirectly affect the trade flows between the two countries of interest. These multilateral resistance terms capture the broader economic dynamics at play.

Since the relative prices of countries involved in the trade are unobserved in the available data, we address this by incorporating country-time fixed effects, following Baldwin and Taglioni (2007). These fixed effects serve to capture country-specific and time-specific factors that could influence trade flows. This gives the following specification:

$$Y_{dot} = c + \alpha RTA_{dot} + \beta X_{dot} + b_{dt} + d_{ot} + \gamma_{do} + u_{dot} \text{ }, \forall d, o, t \tag{3}$$

where d is the destination (importing) country, o the origin (exporting) country, t denotes the year of the trade. b_{dt}, d_{ot}, and γ_{do} are the destination-time, origin-time, and pairs-fixed effects respectively and u_{dot} is the error term. This is our preferred regression which allows us to circumvent the three main errors made by empirical researchers when estimating gravity regressions as pointed out by Baldwin and Taglioni (2007) [8]. We also consider regressions where we include alternative fixed effects as shown in table 7. In Equation (3), the dependent variable (Y_{dot}) is the logarithm of imports from country o to the country d in the year t. The variable of interest, RTA_{dot}, is a binary variable equal to 1 when the countries d and o are part of a Regional Trade Agreement (RTA) in year t, and 0 otherwise. The control variables X include several factors that may influence trade flows between the countries. To account for differences in country size, we control for the logarithm of the GDP of the exporting country (ln_gdp_o) and the importing country (ln_gdp_d). We also include a binary variable indicating whether the countries share a common language, and a contiguity variable indicating whether they share a border. Moreover, we control for the effect of distance on trade flows by including the logarithm of the distance between the capitals of the two countries. This is because, as shown in Figure 8 in the appendix, countries in the same RTA tend to be geographically close. We also tested an alternative measure of distance based on the distance between the most populated cities, and the results were consistent. [9]

To address the possibility of unobservable events that might affect trade flows, we include fixed effects for each year and fixed effects for the exporting and importing countries. We use robust standard errors to account for arbitrary patterns of heteroskedasticity in the data. To address potential correlation within groups, we cluster the standard errors by country pair, as suggested by Moulton (1990). This is because the errors are likely to be correlated within each country pair, regardless of the direction of trade. To enable clustering, we used the distance which uniquely identifies each

[8]Specifically, the trade between a pair of countries depends on the prices of all the partners of this pair, which is sometimes referred to as multilateral resistance term. Failing to account for that is what is called the "gold medal error". To correct this error we include the country-time fixed effect. See Baldwin and Taglioni (2007) for further explanation.

[9]Note that in some regressions not presented here, we restrict the countries to be around a certain distance. different thresholds have been considered varying from 2,000 km to 10,000 km by step of 1,000km. In all these cases, the results still hold: being part of a RTA increases trade significantly between members relative to non-members. This also means that it's not only because countries are close that they necessarily trade more, being part of the same RTA plays a major role in trade.

country pair. By doing so, we obtain more accurate statistical inferences.

A well-known problem with trade data is zero trade among many countries. Even using aggregate trade data, Helpman et al. (2008) reports that around half of the bilateral trade matrix is filled with zeros, this issue is also true for our data. Such observations are dropped from the OLS model because the logarithm of zero is undefined. However, they are relatively common in the trade matrix, since not all countries trade with all partners every year. Dropping zero observations in the way that OLS does potentially lead to sample selection bias. This makes the Pseudo Poisson Maximum Likelihood (PPML) estimator becoming steadily more popular in the literature since this approach allows us to include observations for which the value of trade is zero (Silva and Tenreyro, 2006). We therefore add PPML estimates in the results presented in Table 5 below.

Table 5: Relation between bilateral trade flows and RTA in Africa

	OLS	PPML	OLS	PPML	OLS	PPML	OLS	PPML
rta	1.394***	1.460***	1.268***	1.203***	0.973***	0.734***	0.772***	0.638***
	(0.171)	(0.121)	(0.174)	(0.123)	(0.175)	(0.140)	(0.227)	(0.232)
ln_distcap	-1.949***	-0.155**	-1.632***	-0.106				
	(0.123)	(0.063)	(0.125)	(0.070)				
ln_gdp_o	0.448***	0.110	0.433***	0.077	0.361***	0.140		
	(0.099)	(0.097)	(0.097)	(0.097)	(0.097)	(0.088)		
ln_gdp_d	0.532***	0.716***	0.523***	0.709***	0.516***	0.702***		
	(0.121)	(0.121)	(0.120)	(0.125)	(0.125)	(0.118)		
1 = Common_language			1.014***	0.427***				
			(0.103)	(0.085)				
=1 if contiguous			0.928***	0.551***				
			(0.220)	(0.137)				
Constant	10.141***	1.122	8.327***	1.182	-6.294***	0.520	11.972***	14.873***
	(2.810)	(2.813)	(2.775)	(2.919)	(2.381)	(2.592)	(0.227)	(0.076)
Adjusted R2	0.556		0.573		0.746		0.758	
Obs.	21795.000	35149.000	21795.000	35149.000	21795.000	31534.000	22339.000	23983.000
Years FE	T	T	T	T	T	T	F	F
Destination FE	T	T	T	T	F	F	F	F
Origin FE	T	T	T	T	F	F	F	F
Country Time FE	F	F	F	F	F	F	T	T
Pairs FE	F	F	F	F	T	T	T	T

Note: *The regressions use bilateral trade flows among African countries over the period 1995-2019. Country-time FE stands for origin-time fixed effects (FE) and destination-time fixed effects, which control for each country-specific time-varying factors. We also used robust standard errors and clustered them by country pairs to address potential heteroskedasticity and correlation in the data. The sample for the Poisson regression has been limited to 2000-2019.* * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results presented in Table 5 demonstrate that all of the control variables have the expected signs. Specifically, distance is found to have a statistically significant negative association with bilateral imports, while speaking the same language is positively associated with trade. Similar results were obtained with respect to the GDPs of the countries involved. Moreover, our analysis shows that being part of a Regional Trade Agreement (RTA) leads to a substantial increase in trade, with a predicted rise of 77%.

One of the main endogeneity issues in our analysis is the potential reverse causality between trade and the adoption of regional trade agreements (RTAs). Trade may lead to the adoption of RTAs, but RTAs may also cause higher trade. To account for this reverse causality, our final regression model in table 7 includes country pairs fixed effects, origin-time fixed effects, and destination-time fixed effects. By doing so, we are able to compare the effect of changes in RTA on trade for fixed trade partners. Specifically, we estimate the effect of moving from a no-RTA situation to an RTA situation between country pairs instead of comparing countries in RTA to countries, not in an RTA. With country time fixed effects, we also account for trends in trade, taking into account the fact that trade could have increased over time even without the RTA. Our results show that the adoption of the RTA leads to a significant 77% increase in trade. The estimate for the Poisson model is around 63%. The fact that the estimate is relatively close to the OLS' indicates that the selection bias that it was used to address may not be severe. It is worth noting that in this regression, we cannot estimate variables that are constant across time in country pairs, such as distance.

Our preferred regression remains the OLS estimates and we would like to interpret the Poisson regression as a robustness check. Indeed, all the zeros are not necessarily zeros because of missing data. Zero is given to any country pair during a specific year where the data is not reported. These "false zeros" could also create a bias. For instance, because before 2000 there was little data available we end up with many zeros which creates collinearity issues when running the Poisson regression with many fixed effects. For this reason, we restrict the sample between 2000 and 2019 for the Poisson regressions. Also given that the Poisson model is sensitive to extremely high values, we eliminate the top 5% trade data in these regressions. Overall the RTA effects results are close to the OLS estimates.

Other potential problems with the TWFE

Interpreting the TWFE estimator as a causal effect should not be systematic. Indeed TWFE can estimate the Average treatment effect(ATE) if the parallel trend assumption holds and the effect is constant over time and across groups adopting the RTA(see De Chaisemartin and d'Haultfoeuille (2022))[10]. Unlike the first one, the second assumption is less likely to hold in practice because the effect of RTA on trade is certainly heterogeneous across RTAs Ngepah and Udeagha (2018). The results should therefore be tested against estimators which are robust to heterogeneous treatment effects. When the constant treatment assumption across time and group fails in a staggered adoption design the TWFE estimator might be biased for two main reasons. (i) The weights of TWFE are decreasing over time. This might be a problem if one believes that the effect of the treatment takes time to materialize. (ii) Some of the weights may be negative, and in that case, even if the effect is positive for a unit, negative weights could lower the whole effect. Or even if the effect for a particular unit is negative, by multiplying by the negative weight we'll have a positive effect (De Chaisemartin and d'Haultfoeuille (2020)). Despite these potential limitations, we should not necessarily reject TWFE estimations but complements them with other estimators (De Chaisemartin and d'Haultfoeuille (2022)), which is the aim of the following section. In addition, event studies allow to test for the parallel trend assumption and to see the dynamic effect of the treatment over time.

2.4.2 Event study regressions

Based on the previous criticisms of the TWFE estimator, we use state-of-the-art event study estimators as robustness checks of our previous estimates. Indeed the effects of the regional trade agreement (RTA) on trade is a staggered treatment design with a binary

[10]By group we mean countries which have adopted RTA is the same year.

treatment allowing us to use many recent estimators adapted to these circumstances. Here we rely on standard event studies and robust DID estimators for heterogeneous effects.

Standard Event study

Estimating event specification in equation 4 provides two key pieces of information not observable in this single-coefficient model in equation 3. Firstly, the full set of event leads allows for the inspection of parallel trends in the pre-treatment period. Unbiased estimation of post-event treatment effects relies fundamentally on this assumption. While this does not provide evidence that the units in which the event was adopted and not adopted would have necessarily followed similar trends in the post-rta period it can give an idea of the direction of the potential bias.

Secondly, the policy lags allow for inspection of the temporal nature of treatment effects. This approach allows for a closer inspection of the timing and duration of treatment effects, enabling the identification of potential patterns such as changes in the magnitude or direction of effects over time. Moreover, the analysis can also help to distinguish between transitory and permanent effects, shedding light on the long-term implications of regional trade agreements. By incorporating a temporal dimension into the analysis, the study provides a more comprehensive understanding of the dynamics of the effects of RTAs in Africa, with important implications for policy design and evaluation.

Similar to the approach in Clarke and Tapia-Schythe (2021) we adopt the following specification:

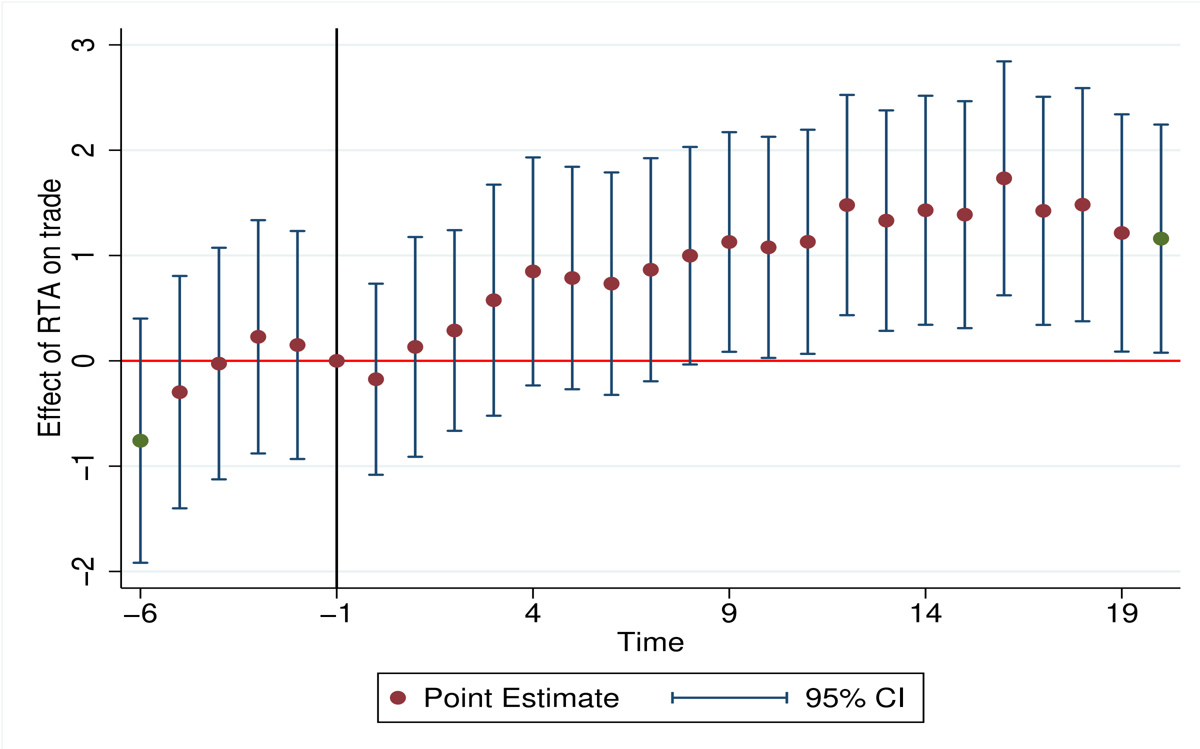
$$y_{odt} = \alpha + \sum_{j=2}^{J} \beta_j (Lag\ j)_{odt} + \sum_{k=1}^{K} \gamma_k (Lead\ k)_{odt} + \mu_{ot} + \lambda_{dt} + F_{od} + X'_{odt}\Gamma + \epsilon_{odt} \tag{4}$$

Here μ_{ot}, λ_{dt} and F_{od} are origin country time-fixed effects, destination country time-fixed effects, and pair fixed effects, X_{odt} are time-varying controls, and ϵ_{odt} is an unobserved error term. In equation 4, lags and leads to the event of interest are defined as follows:

$$(Lag\ J)_{odt} = 1[t \leq Events - J] \tag{5}$$
$$(Lag\ j)_{odt} = 1[t = Events - j] \quad j \in 1, \ldots, J-1 \tag{6}$$
$$(Lead\ k)_{odt} = 1[t = Events + k] \quad k \in 1, \ldots, K-1 \tag{7}$$
$$(Lead\ K)_{odt} = 1[t \geq Events + K] \tag{8}$$

Lags and leads are binary variables indicating that the given state was a given number of periods away from the event of interest in the respective time period. J lags and K leads are included. As indicated in equations 5 and 8, final lags and leads "accumulate" lags or leads beyond J and K periods. A single lag or lead variable is omitted to capture the baseline difference between pairs with RTA and pairs without RTA. In the specification of equation 4, this baseline omitted lag is the first one, where j = 1.

Figure 2: Effect of RTA on imports



Notes: The regression includes origin time, destination time, and pairs fixed effects, this is our preferred regression from the previous gravity part (see equation 3). Data are from 2001 to 2019 because of few countries in RTA prior to 2001 (see figure 10. The horizontal axis presents the time to treatment. Time= -1 is the reference period and means we are evaluating the effect of RTA one year before it has been adopted. the vertical bar around each point displays the confidence interval at 5% level.

The findings of this study are displayed in Figure 2, with the horizontal axis indicating the time before (negative) or after (positive) the adoption of the regional trade agreement (RTA) between two countries. The results reveal a clear pattern, showing no discernible effect of the RTA prior to its adoption (time 0). This finding supports the parallel trend assumption and suggests that the RTA had no significant impact on trade prior to its adoption. Moreover, the results suggest that the effect of the RTA is not immediate, with a positive effect observed only one year after the RTA adoption. However, this effect only becomes significant at a 5% level after eight years following the adoption. This highlights the importance of examining the temporal nature of treatment effects and identifying any dynamics, such as the growth or shrinkage of effects over time, or whether effects are transitory or permanent. Interestingly, the results show that the effect of the RTA increases over time and appears to be permanent, with an increase in trade of more than 150% observed 16 years after the adoption of the RTA. These findings suggest that the RTA has a lasting and positive effect on bilateral trade flows between countries. It is worth noting that while alternative estimation procedures may be preferred to avoid the imbalanced lags and leads observed in this study, the current results provide valuable insights into the temporal dynamics of the impact of RTAs on trade.

But similar to TWFE Sun and Abraham (2021) show that the coefficients of the regression in equation 4 may be biased when the effect is heterogeneous across time or groups. And then testing the parallel trend assumption (or placebo tests) in this setting is not recommended. But the proposed estimator by Callaway and Sant'Anna (2021) is robust to heterogeneous treatment effect and is a more suitable model when one is interested in testing the parallel trend assumption De Chaisemartin and d'Haultfoeuille (2022).

Heterogenous robust DID estimators

The Callaway and Sant'Anna (2021) DID estimator provides a framework to estimate the Average Treatment Effect on the Treated (ATT) for groups that receive treatment at different periods. This method accounts for treatment effect heterogeneity across groups and over time. For a group of units first treated at period g, in calendar time t, the ATT is defined as:

$$ATT(g,t) = E[Y_t(g) - Y_t(0)|G_g = 1] \quad \text{for} \quad t \geq g$$

where Y_t is the outcome of interest at time t, in our case the imports from an origin country to a destination country, $G_g = 1$ if the country pair adopted an RTA for the first time at period g, and $Y_t(g)$ and $Y_t(0)$ are the potential imports from the origin country to a destination country at time t with and without RTA, respectively.

The main assumption underlying this method is the parallel trends assumption, which posits that, in the absence of RTA, the expected change in the imports variable for the treated group (countries adopting RTAs) would have followed the same trend as the control group (countries never adopting RTAs). Formally, for each $t \in \{2, \ldots, T\}$ and $g \in G$ such that $t \geq g$, we assume:

$$E[Y_t(0) - Y_{t-1}(0)|G_g = 1] = E[Y_t(0) - Y_{t-1}(0)|C = 1] \quad \text{a.s.}$$

where $C = 1$ denotes the control group that is never treated. The set G represents all possible periods where an RTA has been adopted the first time. This assumption implies that any difference in the imports between the treated (countries adopting RTAs) and control groups (countries never adopting RTAs), after accounting for the timing of treatment, can be attributed to the RTA adoption.

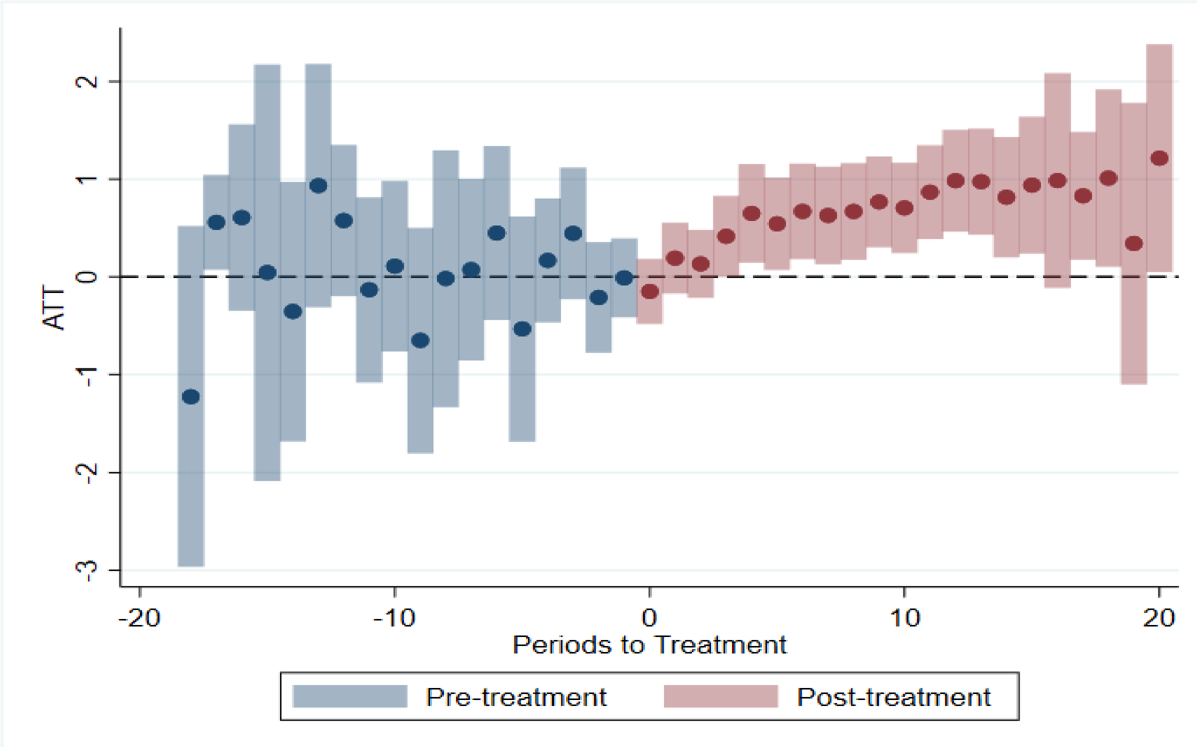
Using this parallel trends assumption, the ATT can be estimated as:

$$ATT(g,t) = E[Y_t - Y_{g-1}|G_g = 1] - E[Y_t - Y_{g-1}|C = 1]$$

where $E[Y_t - Y_{g-1}|G_g = 1]$ represents the observed change in the outcome for the treated group from just before treatment to time t, and $E[Y_t - Y_{g-1}|C = 1]$ represents the observed change for the control group over the same period. This approach allows for a more flexible and robust estimation of treatment effects when dealing with staggered adoption of treatment across different groups.

The results obtained using this DID estimator, illustrated in Figure 3, provide significant insights into the effects of Regional Trade Agreements (RTAs) on intra-African trade over time.

Figure 3: Effect of RTA on imports



Notes: This figure presents the estimation of Callaway and Sant'Anna(2021). The horizontal axis presents the time to treatment. The vertical bars around each point display the confidence interval at 5% level. The overall ATT effect is 62% and is significant at 1% confidence interval level. The estimation is based on data from 1995 to 2019.

The horizontal axis represents the time before and after the adoption of an RTA between two countries, with negative values indicating the pre-treatment period and positive values indicating the post-treatment period. The vertical axis shows the estimated effect of the RTA on trade, with the vertical bars around each point representing the 95% confidence interval.

Before the adoption of the RTA, the graph shows no discernible effect on trade, which supports the parallel trends assumption. This indicates that there were no significant differences in trade trends between the treated and control groups [11] prior to the implementation of the RTA. Following the adoption of the RTA, a positive effect on trade is observed one year after the RTA adoption. However, this effect is not immediately significant at the 5% level. The effect becomes statistically significant at the 5% level approximately five years after the RTA adoption, highlighting a delayed but growing impact of the RTA on trade. Over time, the effect of the RTA on trade continues to increase, indicating a substantial and lasting impact. The aggregated effect is estimated at 62% [12], which means that the adoption of Regional Trade Agreements (RTAs) in Africa has led to an overall increase in trade by 62% over the period 1995 to 2019. This figure is statistically significant at the 1% confidence level, indicating a

[11] We alternatively used both Never Treated (presented here) and Not yet Treated as control groups, the results are similar.

[12] A description of the Weighting is presented in Appendix A.1, but for more details see Callaway and Sant'Anna (2021).

strong and robust impact of RTAs on enhancing trade flows between the participating countries.

In this section, we present two important results separately. First, trade transmits political and climatic shocks to inflation across African countries. Second, existing RTAs are effective in increasing trade by more than 60%. These two results raise many other questions. For instance, what are the implications of RTAs for countries' monetary policies? What should Central Banks in Africa do to better manage the potential effects of shocks from their trading partners following the implementation of the AfCFTA? In the next section, we build a model to provide some answers to these questions.

3 The model

In the model, we consider three countries, each with different levels of risk (productivity)[13]. Agents in the model include representative consumers and firms (both final and intermediate). Countries import and export intermediate goods to produce their non-tradable final good. *Intermediate Goods Market*: each firm produces a unique variety with its own price, which varies between countries. Countries trade in intermediate goods. *Final Goods Market*: Final goods are aggregated from intermediate goods. These goods can be used to consume and also to invest in the production of the intermediate good. Every period, each country experiences a shock drawn from an independent and identically distributed (iid) Fréchet distribution in the intermediate tradable good sector. Following Eaton and Kortum (2002), we assume that the shape parameter of the Fréchet distribution, which governs the relative comparative advantage (θ), is constant but can vary between countries. Home bias is implicitly considered through bilateral trade costs, such as distance and tariffs.

Consumers

The representative consumer's optimization problem is given in country j by:

$$\max_{K_{jt+1}, C_{jt} \geq 0} E_0 \sum_{t=0}^{\infty} \beta^t U(C_{jt})$$

subject to:

$$C_{jt} + K_{jt+1} - (1 - \delta_j) K_{jt} = \frac{r_{jt}}{P_{jt}^Y} K_{jt}$$

Intermediate Goods-Producing Firms

Each country j produces a variety $i_j \in I_j \subseteq [0, 1]$. The profit maximization problem for an intermediate goods-producing firm is:

$$\max_{K^x(i_j)} \Pi^x(i_j) = p(i_j)x(i_j) - r_j K^x(i_j)$$

[13] The model is still in its early stages, but we have laid out some foundational concepts to help frame our research questions, particularly focusing on how Regional Trade Agreements (RTA) transmit inflation across trading partners. Here, we present the basis of the model along with some preliminary

subject to:

$$x(i_j) = \frac{K^x(i_j)}{a_j(i_j)}$$

where $a_j(i_j)$ and $p(i_j)$ represent the unit capital requirements and the supply price, respectively. The zero-profit condition implies:

$$p(i_j) = a_j(i_j) r_j$$

Let A_j be an iid random variable for $a_j(i_j)$. As in Eaton and Kortum (2002), A_j^{-1} follows a Fréchet distribution:

$$F_j(z) = Pr(1/A_j \leq z) = \exp(-b_j z^{-\theta})$$

where $b_j > 0$ and $\theta > 1$.

We consider iceberg trade costs: shipping τ_{nj} units from country j delivers one unit to country n ($\tau_{nj} \geq 1$). Producing variety i_j in country j and delivering it to country n costs:

$$p_{jn}(i_j) = \tau_{nj} p(i_j)$$

The demand price of variety i in country n is:

$$P_n(i) = \min(\{p_{nj}(i)\}_{j=1}^{N})$$

Final Goods-Producing Firms

Shocks z_n in the final good sector in country n, represented as labor productivity shock, are drawn from an iid AR(1) distribution for each country. The profit maximization problem for final goods-producing firms is:

$$\max_{x_n} \Pi_n^Y = P_n^Y Y_n - \int_0^1 P_n(i) x_n(i)\, di$$

subject to:

$$Y_n = z_n \left(\int_0^1 x_n(i)^{\frac{\sigma_n - 1}{\sigma_n}}\, di \right)^{\frac{\sigma_n}{\sigma_n - 1}}$$

where z_n is the productivity and P_n^Y is the price of the final good in country n. From Lemma 1 in Naito, we have:

$$P_n^Y(\{\tau_{nj} r_j\}_{j=1}^{N}) = c_n \left[\sum_{j=1}^{N} b_j (\tau_{nj} r_j)^{-\theta} \right]^{-1/\theta}$$

where $c_n = z_n^{-1} \Gamma\left(1 + \frac{1-\sigma_n}{\theta}\right)^{\frac{1}{1-\sigma_n}}$ and Γ is the gamma function.

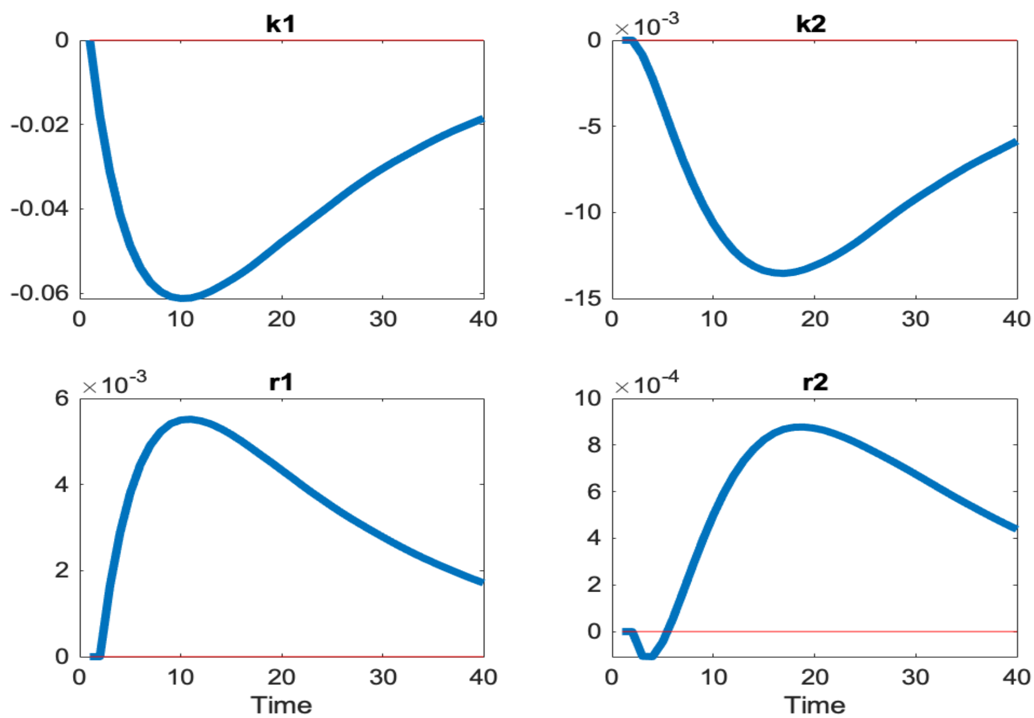
simulations to build intuition.

4 Results

We take a basic calibration with standard parameters. The only important feature to notice is that the trade cost between country 2 and country 1 is half of the trade cost that country 3 has with the others. This means that only countries 1 and 2 have signed a Regional Trade Agreement.

Figures 4 and 5 present the simulation of the model variables after a one standard deviation shock in country 1's final good sector productivity. In figure 4, $k1$ (respectively $k2$) represents the ratio of country 1's (respectively country 2's) capital to that of country 3, which has been normalized to one. Similarly, $r1$ (respectively $r2$) is the relative capital of country 1 (respectively country 2) to country 3, also normalized to one.

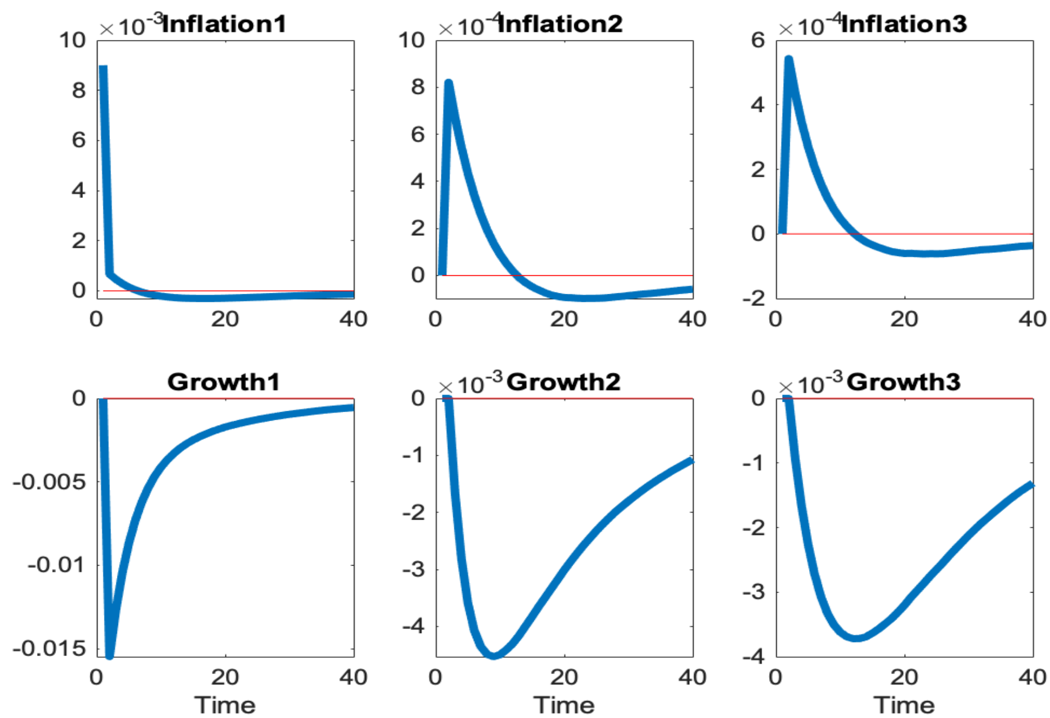
Figure 4: Relative capital and interest rate dynamics



Notes: *This figure displays the comparative capital and interest rates of country 1 and country 2 relative to those of country 3 following a one standard deviation in country 1's final good productivity.* $k1$ *(respectively* $k2$*) represents the ratio of country 1's (respectively country 2's) capital to that of country 3, which has been normalized to one. Similarly,* $r1$ *(respectively* $r2$*) is the relative capital of country 1 (respectively country 2) to country 3, also normalized to one. All the variables are expressed as a percentage deviation from the steady states.*

After the shock in country 1, the capital decreases to reach its minimum of -6% after 10 periods. The recovery is relatively slow toward the balanced growth path. Because capital becomes scarce, the interest rate increases. We see similar results in country 2 but with a lower magnitude. Indeed, capital in country 2 reaches its minimum after nearly 20 periods (compared to 10 in country 1) but with a minimum of approximately -0.13% (compared to -6% in country 1). We observe similar results for the interest rate. Thus, besides the fact that the effect is lower in magnitude in country 2, it lasts longer than in country 1. This is because of the importance of trade between country 1 and country 2. Indeed, as shown in Figure 16 in the appendix, when country 1 and country 2 enter the regional trade agreement, the trade share of country 2 from country 1 increases. Consequently, when there is a negative productivity shock in country 1, country 2's trade share in intermediate goods from country 1 decreases, which reduces its final goods production and thus the capital (as capital investment in the model comes from the final good). Overall, this means that country 2 cannot fully recover until country 1 has recovered, explaining the delayed effects in country 2.

Figure 5: Inflation and Growth dynamics



Notes: *This figure presents inflation and growth dynamics following a one standard deviation productivity shock in country 1's final good sector.*

In Figure 5, we can see similar results as in Figure 4 for inflation and growth in all the countries. The most interesting part here is that we can compare the effect of a shock in country 1 on country 2's inflation and growth to similar effects in country 3. Remind that country 2 has an RTA with country 1 while country 3 has no RTA signed.

As can be seen, the shock in country 1 affects country 2's inflation and growth more compared to country 3. Indeed, a negative productivity shock in country 1 increases inflation up to 0.8% in country 2 compared to nearly 0.6% in country 3. We observe similar results for growth. These results highlight the role of RTAs in transmitting shocks across countries [14].

5 Conclusion

In this paper, we document the transmission of climatic and political shocks through trade. Using an instrumental variable strategy, we show that a 1% decrease in imports

[14] We are working to include a Central Bank in the model to study the ability of Monetary Policy

due to these shocks raises inflation in the importing country by 0.4 to 0.58 percent. This underscores the critical role of trade as a conduit for external shocks, with significant implications for inflation dynamics in Africa. Furthermore, we explored the impacts of Regional Trade Agreements (RTAs) on intra-African trade. Our empirical analysis, using a structural gravity model, Pseudo Poisson Maximum Likelihood (PPML) estimation, and an event study, demonstrates that RTAs have significantly increased trade among African countries by 62 to 77 percent from 1995 to 2019. These findings, though lower than most estimates in the existing literature, provide robust evidence of the positive effects of RTAs in enhancing trade in Africa.

In addition to empirical evidence, we developed a theoretical model to assess the broader implications of RTAs for monetary policy. Our simulations indicate that the African Continental Free Trade Area (AfCFTA) could have substantial effects on inflation and necessitate adjustments in monetary policy to maintain economic stability. Overall, our findings highlight the importance of RTAs in boosting trade and their complex role in economic stability. Policymakers should consider these dynamics when designing and implementing trade and monetary policies to harness the full benefits of economic integration in Africa.

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Appendix

A Trade flows and Regional Trade Agreement (RTA)

Table 6: Relation between bilateral trade flows and RTA in Africa

	(1)	(2)	(3)	(4)
rta	1.417***	1.318***	0.891***	0.560**
	(0.206)	(0.211)	(0.180)	(0.252)
ln_distcap	-1.833***	-1.575***		
	(0.157)	(0.162)		
ln_gdp_o	0.359***	0.354***	0.280**	
	(0.112)	(0.109)	(0.108)	
ln_gdp_d	0.597***	0.594***	0.579***	
	(0.140)	(0.139)	(0.143)	
1 = Common official or primary language		0.868***		
		(0.138)		
=1 if origin and destination are contiguous		0.680***		
		(0.253)		
Constant	9.939***	8.148***	-1.965	12.662***
	(2.755)	(2.777)	(2.763)	(0.623)
Adjusted R2	0.546	0.558	0.744	0.763
Obs.	15525.000	15525.000	15525.000	15841.000
Years FE	T	T	T	F
Destination FE	T	T	F	F
Origin FE	T	T	F	F
Country Time FE	F	F	F	T
Pairs FE	F	F	T	T

The regressions use bilateral trade flows among African countries from 1995-2019. Here we keep countries with data available in at least 12 years over the 24. The results of the OLS are stable and close to the benchmark of around 60 % even if we keep at least 5, 10, or 12 years. The Poisson regression is much more unstable. Indeed the presence of many fixed effects increases the collinearity between regressors which could lead to spurious estimates Silva and Tenreyro (2011). Therefore we rely more on the OLS when we vary the sample and the fact that the estimates are consistent gives evidence that the OLS is a good estimator in this case. Country-time FE stands for origin-time fixed effects (FE) and destination-time fixed effects, which control for each country-specific time-varying factors. We also used robust standard errors and clustered them by country pairs to address potential heteroskedasticity and correlation in the data.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Relation between bilateral trade flows and RTA in Africa

	(1)	(2)	(3)	(4)	(5)	(6)
rta	2.146***	1.394***	1.268***	1.325***	0.973***	0.772***
	(0.174)	(0.171)	(0.174)	(0.190)	(0.175)	(0.227)
ln_distcap	-1.351***	-1.949***	-1.632***	-1.602***		
	(0.096)	(0.123)	(0.125)	(0.133)		
ln_gdp_o	1.070***	0.448***	0.433***		0.361***	
	(0.038)	(0.099)	(0.097)		(0.097)	
ln_gdp_d	0.854***	0.532***	0.523***		0.516***	
	(0.041)	(0.121)	(0.120)		(0.125)	
1 = Common official or primary language			1.014***	0.980***		
			(0.103)	(0.106)		
=1 if origin and destination are contiguous			0.928***	0.983***		
			(0.220)	(0.218)		
Constant	-7.402***	10.141***	8.327***	25.902***	-6.294***	11.972***
	(1.228)	(2.810)	(2.775)	(1.175)	(2.381)	(0.227)
Adjusted R2	0.410	0.556	0.573	0.579	0.746	0.758
Obs.	21795.000	21795.000	21795.000	22339.000	21795.000	22339.000
Years FE	T	T	T	F	T	F
Destination FE	F	T	T	F	F	F
Origin FE	F	T	T	F	F	F
Country Time FE	F	F	F	T	F	T
Pairs FE	F	F	F	F	T	T

The regressions use bilateral trade flows among African countries over the period 1995-2019. Country-time FE stands for origin-time fixed effects (FE) and destination-time fixed effects, which control for each country-specific time-varying factors. We also used robust standard errors and clustered them by country pairs to address potential heteroskedasticity and correlation in the data.

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

In figure 7, we run the same regression by product category. Besides arms and munition (which have few data [15]), for all the products RTA has the right sign and is significant for 16 products out of 21. We also look at the dynamic of the coefficient over time (figure 6). We note that before 2000, we did not have a significant effect that can be explained by a few observations. Indeed, there were only a few RTAs (around 10 [16]) which started around the same period, so their effect was not instantaneous. But after 2000 the effect of RTA on trade is positive, significant, and relatively stable over time.

[15] Although positive, the coefficient is not significant and trade flows for this product account only for 0.02% of total trade flows, see 1

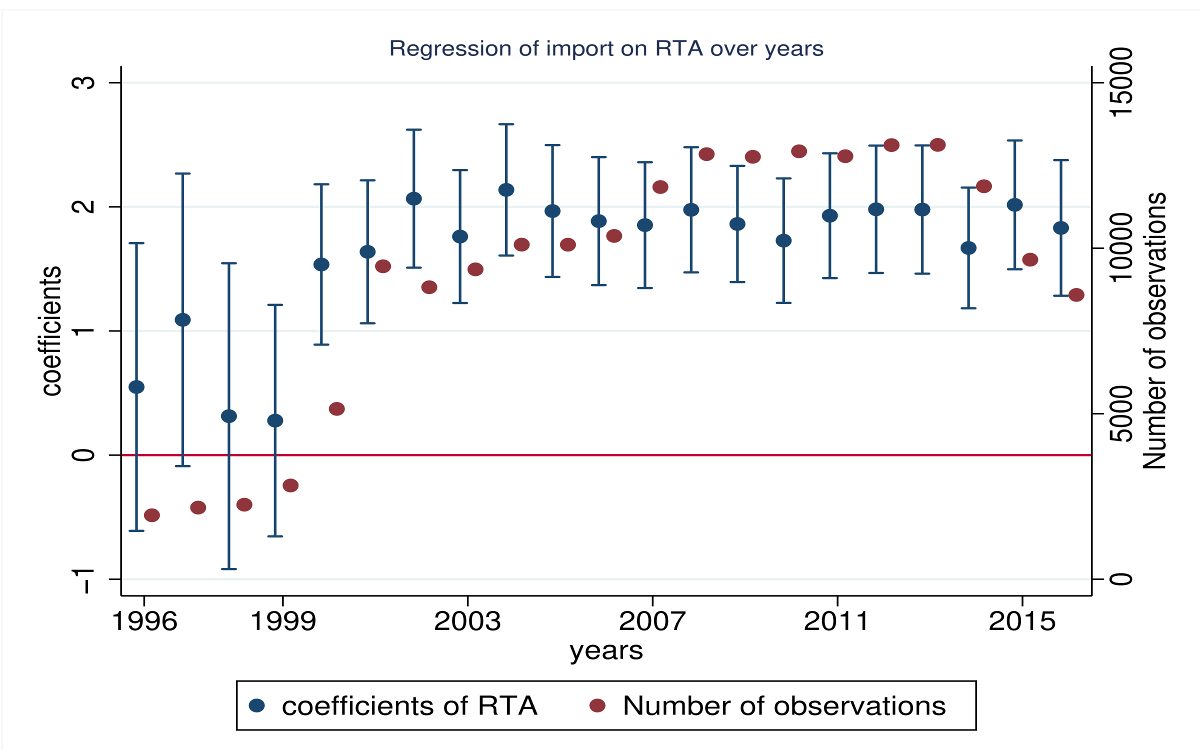
[16] see figure 10 in the appendix

Table 8: Poisson estimation: dependent var *bilateral_import_ij*

	(1)	(2)	(3)	(4)	(5)
rta	2.012***	0.980***	0.805***	0.790***	0.670***
	(0.318)	(0.161)	(0.201)	(0.212)	(0.237)
ln_distcap			-0.765***	-0.760***	-1.245***
			(0.151)	(0.152)	(0.111)
1 = Common official or primary language			0.699***	0.672***	
			(0.206)	(0.208)	
=1 if origin and destination are contiguous			0.849***	0.884***	
			(0.253)	(0.274)	
ln_gdp_o			0.497***		0.476***
			(0.133)		(0.125)
ln_gdp_d			0.006		0.005
			(0.142)		(0.139)
Constant	16.502***	19.253***	14.334***	23.539***	19.151***
	(0.242)	(0.111)	(3.793)	(1.211)	(3.384)
Obs.	22339.000	22213.000	21795.000	22339.000	21795.000
Years FE	T	F	T	T	T
Destination FE	F	F	T	T	T
Origin FE	F	F	T	T	T
Pairs FE	F	T	F	F	F

Notes: The third and fifth regressions are Poisson Pseudo-Maximum Likelihood Estimators. Adding GDP of origins and destinations doesn't change the results much and their coefficient has expected signs.

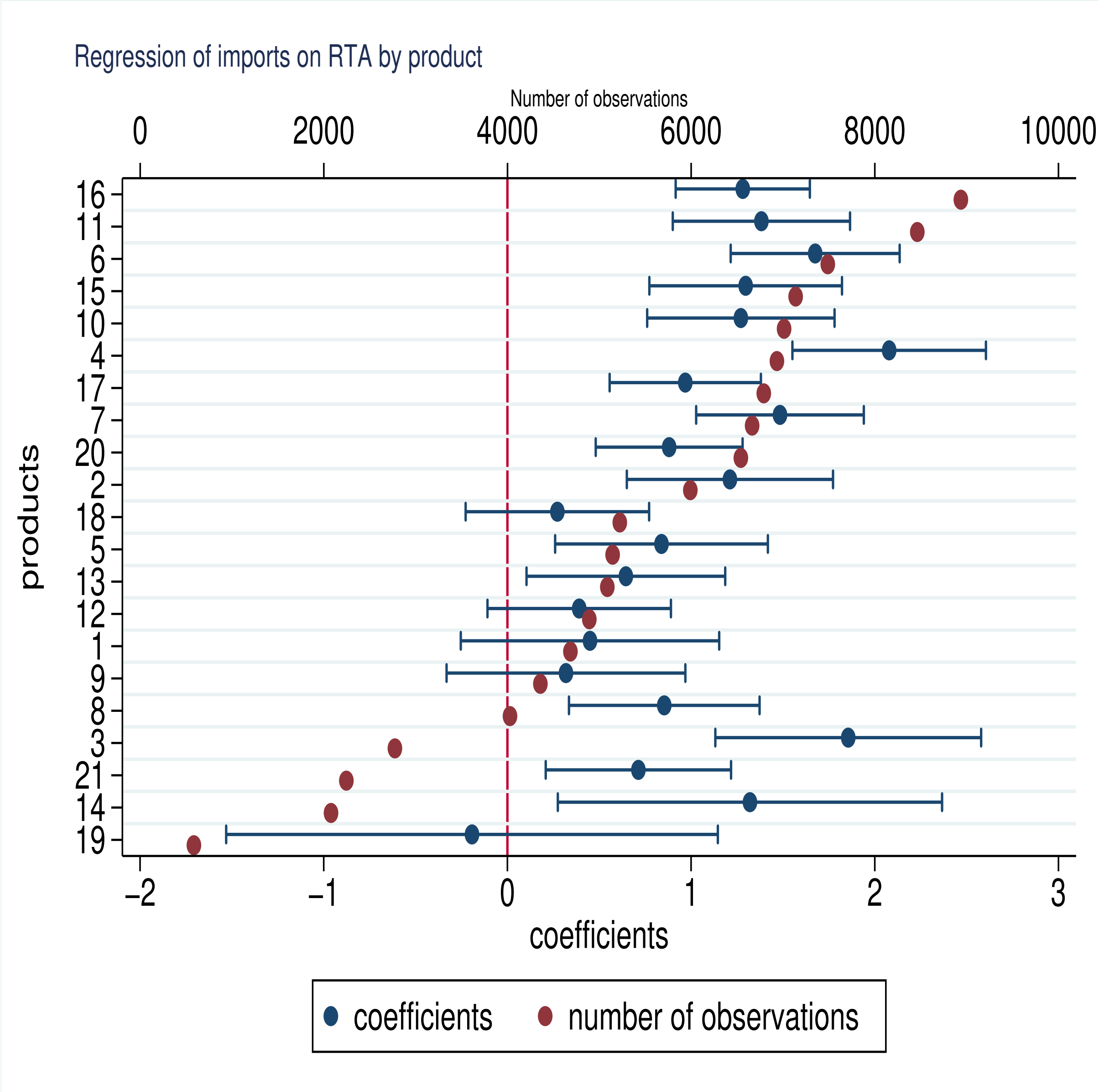
Figure 6: Imports on RTA over time, with all controls



Notes:

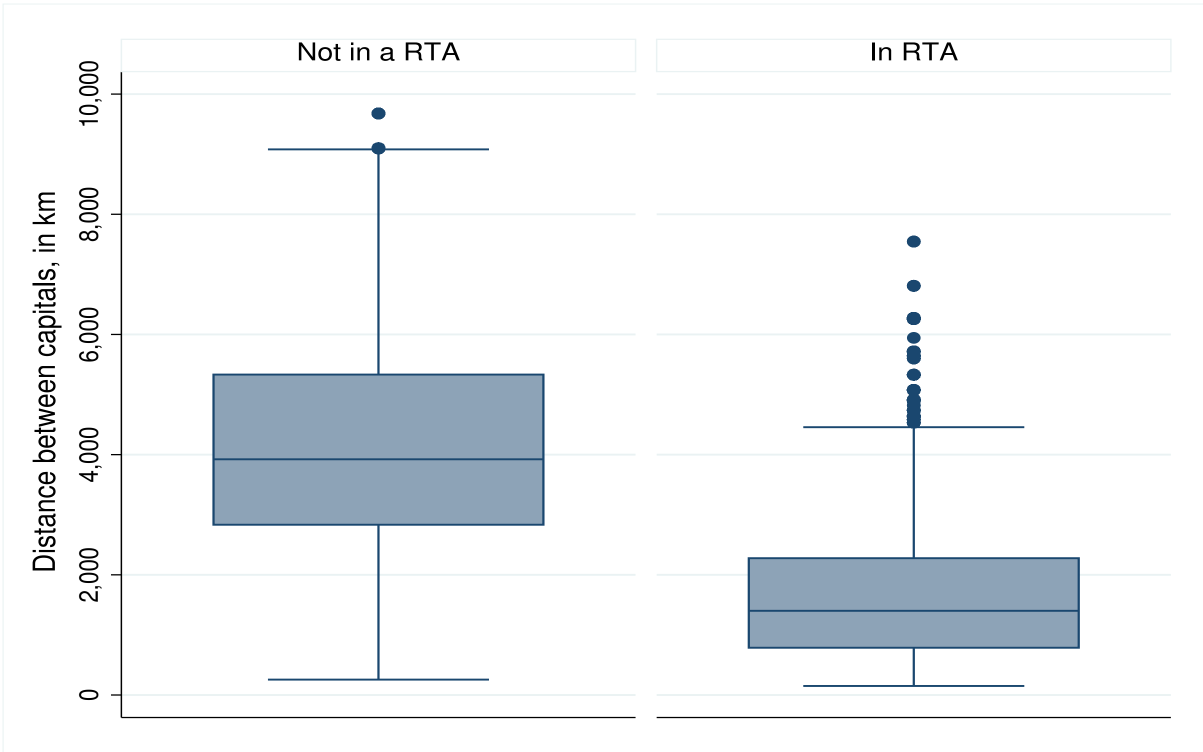
By product

Figure 7: imports on RTA by product, with all controls



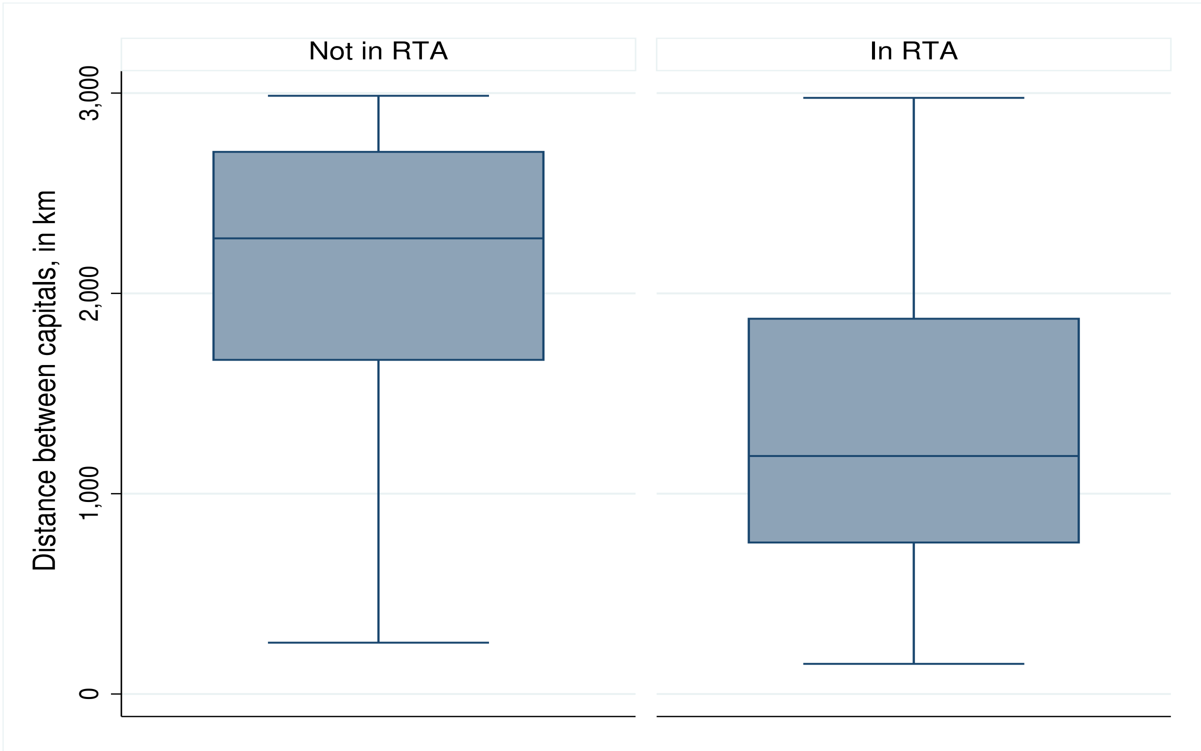
Notes:

Figure 8: box plot of distance by RTA



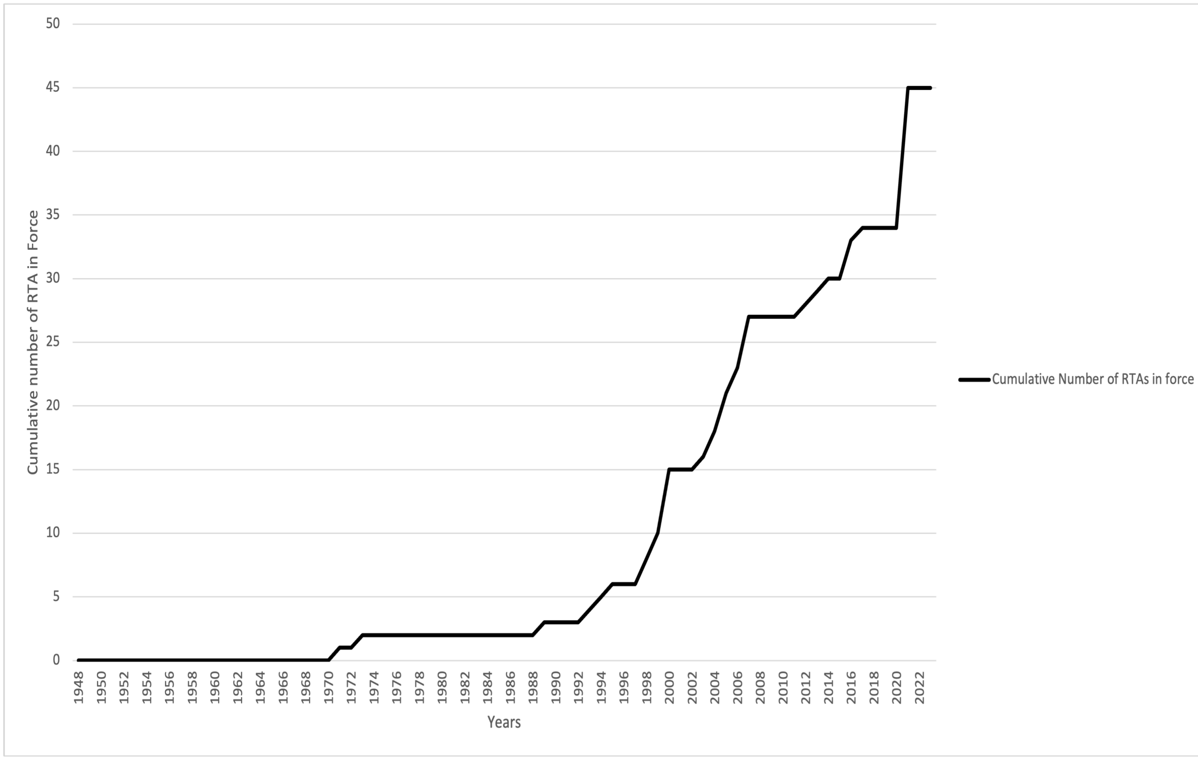
Notes:

Figure 9: box plot of distance by RTA for distance les than 3000km



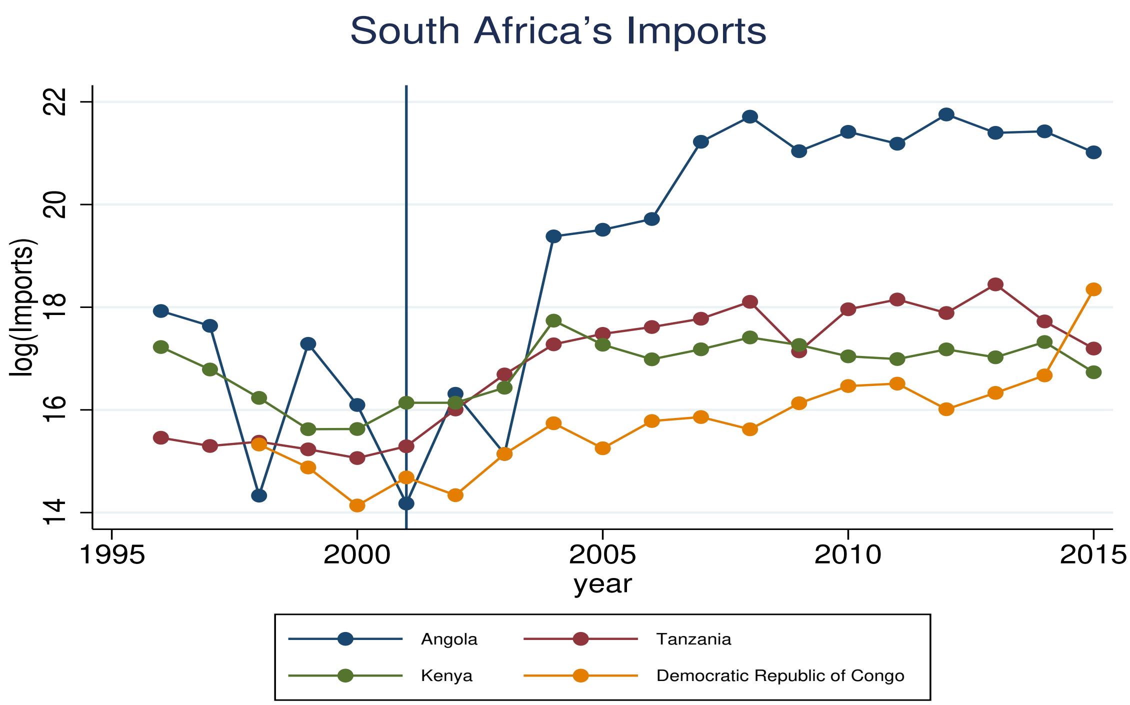
Notes:

Figure 10: cumulative numbers of RTA among African countries



source :WTO

Figure 11



source :WTO

A.1 Weighting Mechanism to aggregate the ATTs

Here we presents how we aggregates the Average Treatment Effects on the Treated (ATTs) across different groups that receive treatment at different times.

Group-Specific ATT Estimation

First, the ATT for each group g at each time t is estimated. Formally, for a group g treated at time g in period t:

$$ATT(g,t) = E[Y_t(g) - Y_t(0)|G_g = 1]$$

where $Y_t(g)$ and $Y_t(0)$ are the potential outcomes with and without treatment, respectively.

Aggregation Over Event Time

Event time k is defined as $k = t - g$, the difference between the calendar time t and the treatment time g. The goal is to aggregate ATTs for the same event time k across different groups.

Let's denote the number of units (e.g., country pairs) in group g as N_g. The overall ATT at event time k can be formulated as:

$$ATT(k) = \frac{\sum_{g \in G_k} N_g \cdot ATT(g, g+k)}{\sum_{g \in G_k} N_g}$$

where G_k is the set of groups that have event time k. This formula represents a weighted average of the ATTs for event time k, with weights N_g proportional to the group sizes.

Overall Aggregated ATT

To get the overall aggregated ATT across all event times, we further aggregate the event time-specific ATTs:

$$ATT = \frac{\sum_{k \in K} W_k \cdot ATT(k)}{\sum_{k \in K} W_k}$$

where:

- K is the set of all event times.
- W_k is the total weight for event time k, typically the sum of the weights of all groups at that event time:
$$W_k = \sum_{g \in G_k} N_g$$

Thus, the overall ATT is a weighted average of the event time-specific ATTs, with the weights reflecting the combined sizes of the groups contributing to each event time. The weighting mechanism ensures that larger groups and more frequently observed post-treatment periods contribute more to the overall effect. This approach leverages the flexibility of the Difference-in-Differences (DID) estimator to handle treatment effect heterogeneity and staggered treatment adoption across different groups and times.

B Trade and shock transmission

Construction of shock data Gridded Population of the World (GPWv4) 30 arc-seconds (approximately 1 km at the equator) population count for the years 2000, 2005, 2010, 2015, and 2020, consistent with national censuses and population registers

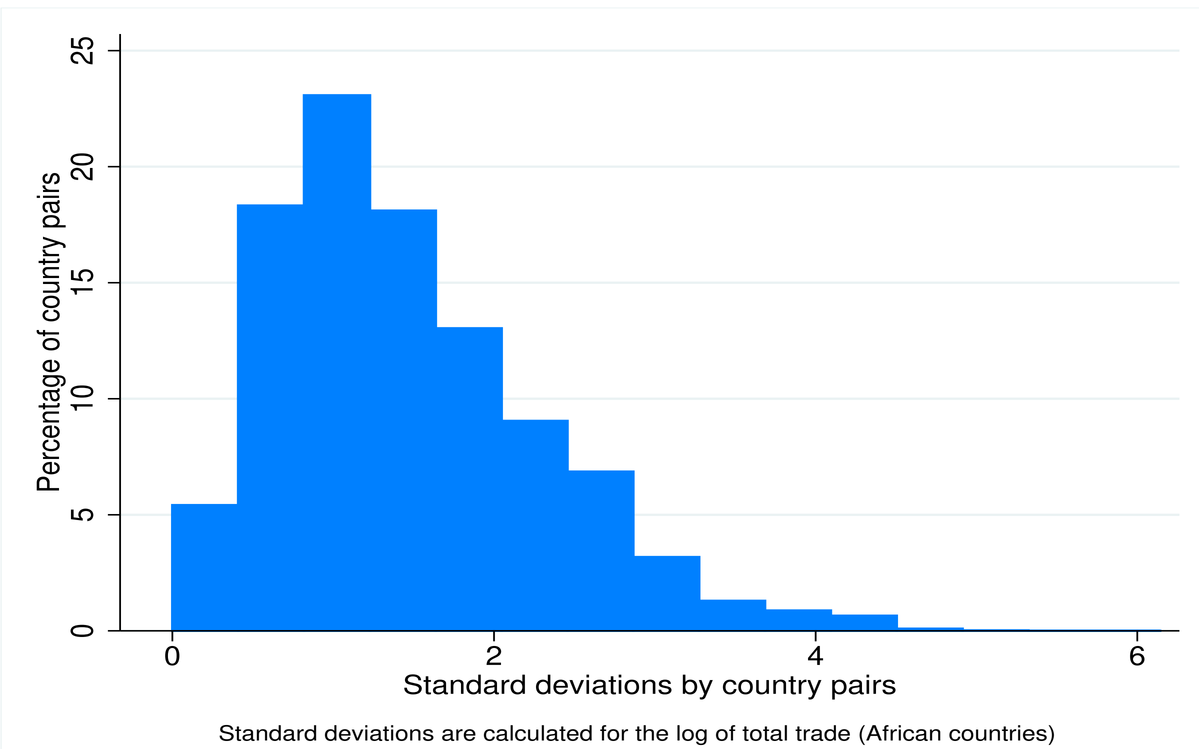
Table 9: IV-regression: inflationary effect of shock-induced trade variations

	(1) infl_cpi_d	(2) infl_cpi_d	(3) infl_cpi_d	(4) infl_cpi_d	(5) infl_cpi_d	(6) infl_cpi_d	(7) infl_cpi_d	(8) infl_cpi_d
log_import_ij	-0.0218	-0.370	3.718	-0.416	-0.00248	-0.393***	-1.298	-0.425***
	(0.0197)	(0.723)	(12.47)	(0.713)	(0.00767)	(0.122)	(16.55)	(0.109)
above_med_supplier_import			-6.648				-0.201	
			(18.37)				(22.85)	
above_Q3_supplier_import				-0.279				-0.108
				(1.189)				(0.460)
Constant	6.238***	8.567*	-27.86	8.705*	1.776***			
	(0.254)	(5.069)	(108.8)	(5.043)	(0.0634)			
Origin * destination FE	T	T	T	T	T	T	T	T
Year FE	T	T	T	T	T	T	T	T
R2	0.646	0.632	-0.539	0.624	0.900	-0.0232	-0.213	-0.0139
Observations	13266	11816	11816	11816	12532	11815	11815	11815
CD Fstat		5.025	0.0493	2.894		4.287	0.0395	1.006
KP Fstat		5.589	0.113	6.342		3.223	0.0840	2.253
KP pval		0.0181	0.736	0.0118		0.0726	0.772	0.133

Notes: Results based on data from 2001 to 2015. Inflation is annually winsorized at 5%. Bilateral import flows are aggregated from the product-level bilateral import data set of the WTO Standards errors are clustered at the Origin * destination level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

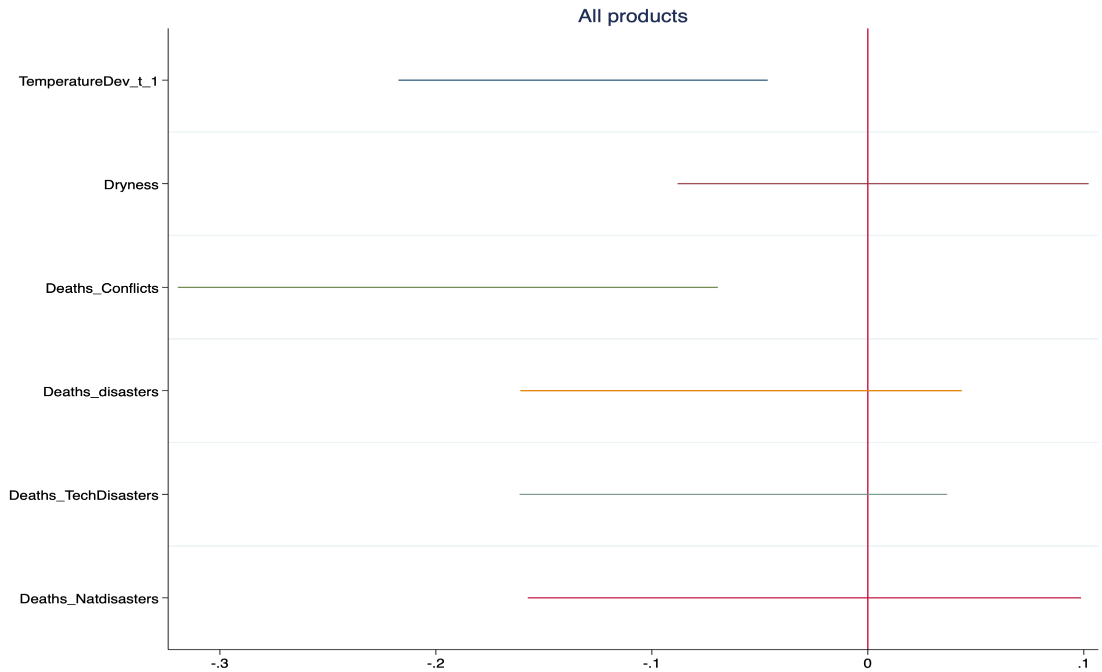
Figure 12: standard deviations of bilateral imports across pair of countries



Notes: This graph presents standard deviations of bilateral imports by pairs of countries. When we also do the same exercise for the most exchanged products "mineral products", we get similar results.

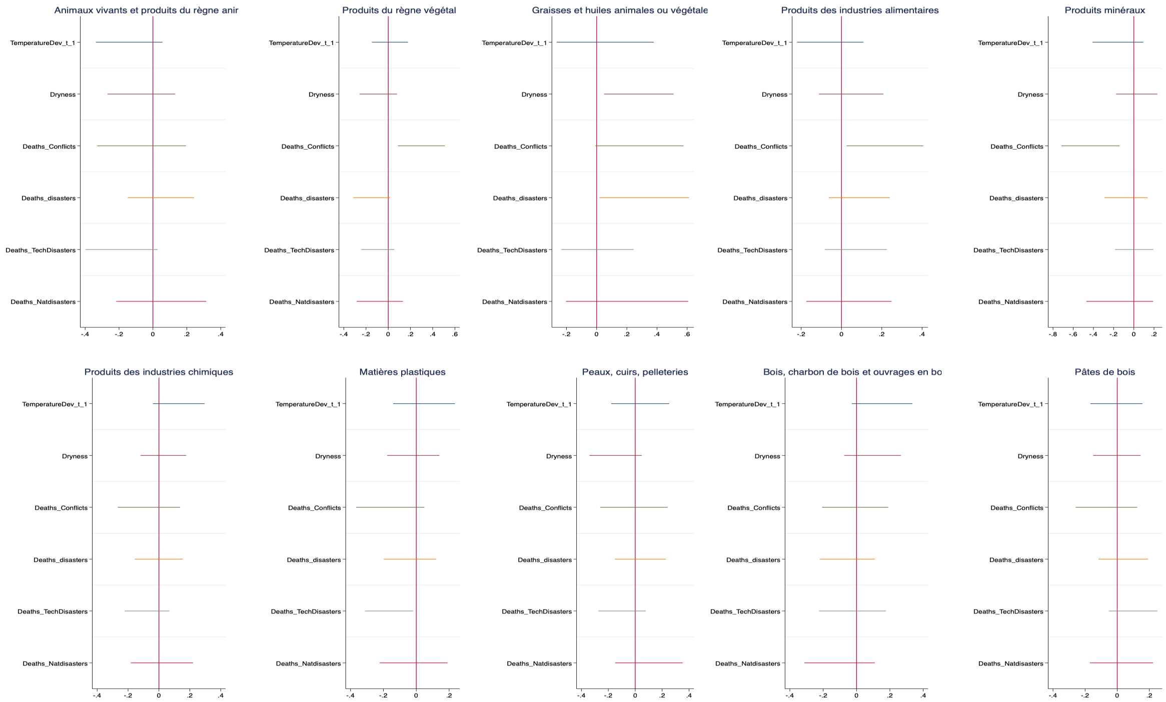
cross African countries.

Figure 13



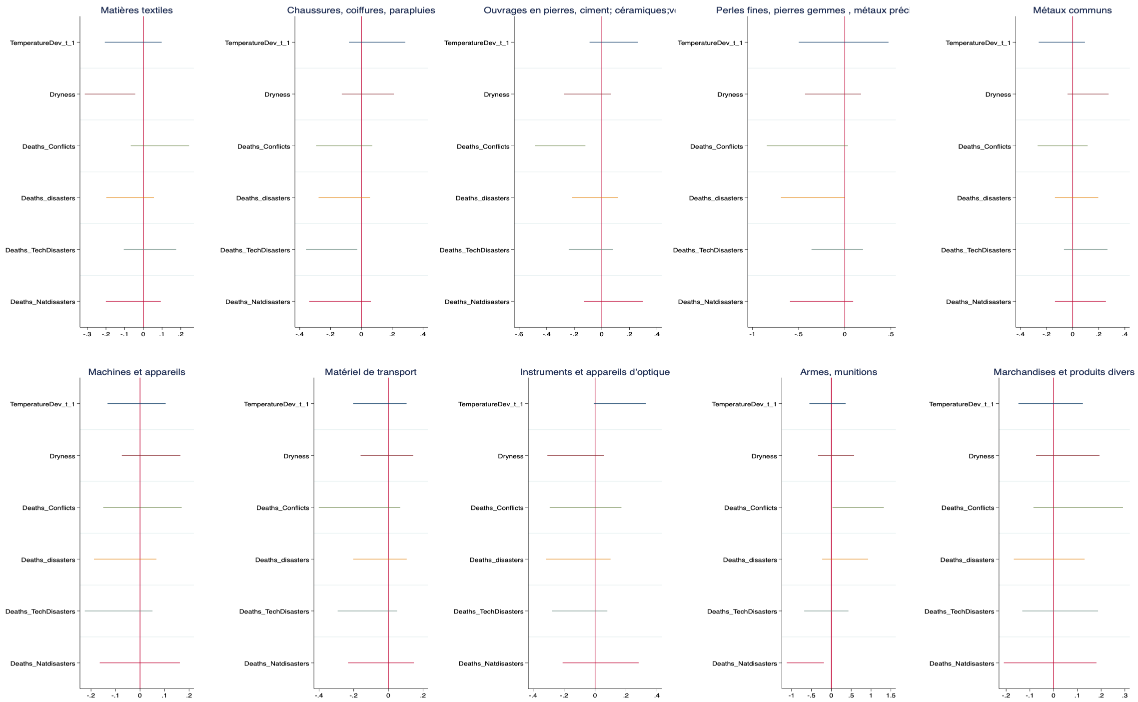
Notes:

Figure 14



Notes:

Figure 15



Notes:

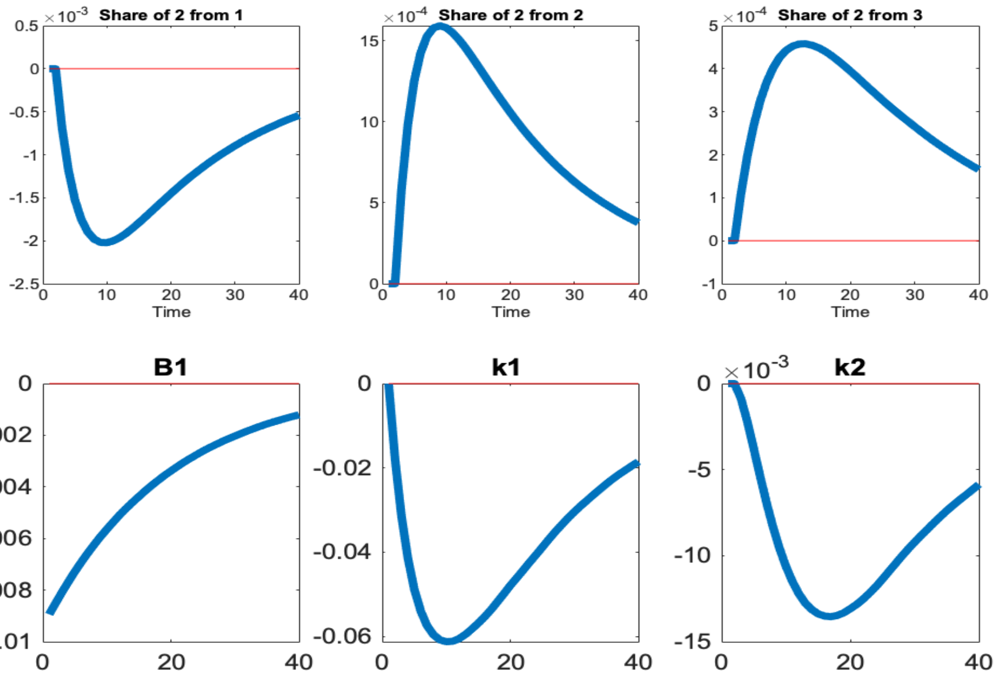
Table 10: First-step regression: shock-induced variations in trade growth

	(1) D_log_import_ij05	(2) D_log_import_ij05	(3) D_log_import_ij05	(4) D_log_import_ij05	(5) D_log_import_ij05	(6) D_log_import_ij05	(7) D_log_import_ij05	(8) D_log_import_ij05
L.temp_pop_c_o	-0.125***	-0.126***	-0.0376**	-0.0408**	-0.115***	-0.116***	-0.0306*	-0.0315*
	(0.0439)	(0.0440)	(0.0167)	(0.0170)	(0.0434)	(0.0435)	(0.0167)	(0.0168)
Id0_ndeath_c_o	-0.109	-0.109	-0.0279	-0.0210	-0.103	-0.102	-0.0343*	-0.0340*
	(0.0680)	(0.0680)	(0.0203)	(0.0219)	(0.0682)	(0.0682)	(0.0198)	(0.0201)
L.temp_pop_c_d		-0.100**		-0.0375***		-0.0853*		-0.0344***
		(0.0441)		(0.0139)		(0.0447)		(0.0130)
Id0_ndeath_c_d		0.0195		-0.0257		0.0394		-0.0251
		(0.0596)		(0.0206)		(0.0585)		(0.0204)
Constant	0.133***	0.139***	0.0437***	-0.0434***	0.139***	0.141***	0.108***	0.112***
	(0.0113)	(0.0150)	(0.00379)	(0.00490)	(0.0113)	(0.0148)	(0.00367)	(0.00471)
Destination FE	F	F	F	F	F	F	F	F
Origin FE	F	F	F	F	F	F	F	F
Origin * destination FE	T	T	T	T	T	T	T	T
Year FE	T	T	T	T	T	T	T	T
R2	0.0609	0.0612	0.291	0.444	0.0436	0.0439	0.0769	0.0772
F-stat	5.849	4.286	3.698	3.807	5.051	3.572	3.332	3.678
Observations	12731	12731	12731	12731	11887	11887	11887	11887

Notes: Results based on data from 2001 to 2015. Bilateral import flows are aggregated from the product-level bilateral import data set of the WTO Standards errors are clustered at the Origin * destination level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Standards errors are clustered at the Origin * destination level.

C Model's results appendix

Figure 16: Country 2 trade share dynamics



Notes: This figure presents the The first row shows the trade share of country 2 from the three different countries.