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Regional trade agreements, globalization, and global maize exports

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Abstract: Globalisation is also having a profound impact on international agricultural trade. This study examines the impact of regional trade agreements (RTAs) and globalization on international maize trade using a gravity model for the period 1996–2020. The results show that, despite globalization, distance has a larger negative impact on bilateral maize trade than on the manufacturing sector. It appears that distance remains an important factor in explaining trade flows in commodity markets, including maize. Our findings on the role of RTAs are in line with the results of previous studies: RTAs are generally preceded by a strengthening of bilateral trade relations. There is mutually positive feedback between the level of bilateral trade and RTA membership. However, the establishment of a common RTA membership and its trade-stimulating effects are not immediately visible.

Keywords: bilateral relationships; distance puzzle; econometrics; gravity model; international trade

There is a rich literature on international trade in commodities, especially in the case of rice or wheat. Although maize plays an important role in global agriculture, research on international maize trade is rather limited. Only a few studies have focused on international maize trade, for example, Jayasinghe et al. (2010) and Haq et al. (2013) for global players and Fertő and Szerb (2017) for small maize exporting countries. However, there are some reasons why trade analysis of maize markets is important.

First, according to the data of FAOSTAT (FAO 2022a), maize is the second most cultivated crop in the world after sugar cane. In modern economies, maize is a strategic product because of its wide range of uses. In addition to human nutrition and animal feed, maize can also be used as a source of raw materials in many areas. Without being exhaustive, maize provides an important raw material base for biofuel production, health products, energy storage, the plastics industry, the construction industry, and many other non-food areas (Amiri and Bundur 2018).

Secondly, between 1996 and 2020, global maize production and exports experienced explosive growth. The area sown to maize increased from 142 million ha to more than 192 million ha, while global average yields also improved by about 43% (from 4.19 tonnes/ha to 6 tonnes/ha). International trade has seen an even more dramatic change. According to the World Bank (2021) data, there has been a significant expansion over the two decades under review. While in 1996, the value of maize exports rarely exceeded USD 12 billion, since 2011, they have repeatedly exceeded USD 40 bil-

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lion, a more than threefold increase in trade (at current prices). The international maize market is highly concentrated, both in terms of production and trade.

Table 1 shows that in 1996, the USA alone accounted for nearly a third of world maize production and, together with China, covered more than half of global production. Brazil, the third largest producer, accounted for just over 4%. By 2020, the aggregated share of leading countries has fallen slightly. The USA continued to increase its production, but its global share fell by 7.5%. China maintained its market share, while Brazil significantly increased its share. Notice that Argentina and Ukraine have replaced Mexico and France as new players in the top 5.

In 1996, the USA dominated exports (Table 2) even more than production. The USA alone accounted for nearly three quarters of global exports. France, the second largest exporter, accounted for less than 10%, while Canada, the fifth largest exporter, accounted for less than 1%. This situation changed significantly by the end of the period under review. Market expansion was concentrated mainly in countries that had previously exported little or nothing. As a result, the USA share of global exports fell to one-fifth. In the top 5 countries, significant changes have taken place, with new players becoming leading exporters. It is worth highlighting the rise of South America and Eastern Europe.

Thirdly, like other agri-food products, the world trade in maize is subject to policy interventions. On the export side, countries use a wide range of export promotion programs, while on the import side, governments use a range of policy measures to protect the internal market. In short, trade policy plays an important role in the global maize market.

This study aims to provide a complete picture of the global maize trade. Specifically, the impact of regional trade agreements (RTAs) and globalization on international maize exports is examined. Particular attention is paid to methodological issues raised by the recent literature (Table 3) in empirical trade analysis, including the trade-distorting effect of domestic sales, the possible endogeneity of RTAs, the possible reverse causality between trade and RTAs, the possible nonlinearity of RTAs.

Table 1. Leading maize producing countries of the world (1996 and 2020)

Year	Countries	Production quantity (tonnes)	Share in global production (%)
1996	USA	234 517 750	32.85
	China	127 865 412	17.91
	Brazil	29 652 791	4.15
	Mexico	18 023 626	2.52
	France	14 318 928	2.01
2020	USA	360 251 560	25.31
	China	260 876 476	18.33
	Brazil	103 963 620	7.30
	Argentina	58 395 811	4.10
	Ukraine	30 290 340	2.13

Source: Authors' compilation/calculation based on FAO (2022a)

Table 2. Leading maize exporting countries of the world (1996 and 2020)

Year	Countries	Production quantity (tonnes)	Share in global production (%)
1996	USA	52 410 000	72.85
	France	6 651 967	9.25
	Argentina	6 424 596	8.93
	South Africa	1 948 230	2.71
	Canada	512 700	0.71
2020	USA	51 838 933	26.87
	Argentina	36 881 996	19.12
	Brazil	34 431 936	17.85
	Ukraine	27 952 483	14.49
	Romania	5 651 064	2.93

Source: Authors' compilation/calculation based on FAO (2022b)

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Table 3. Application of gravity models in agriculture

Authors	Examined data	Results
Sarker and Jayasinghe (2007)	trade survey of EU-15 6 priority agricultural products between 1985–2000	The EU-15 countries continuously increased their trade with each other during the period under review. This was positively affected by the size of the country and negatively by distance.
Jayasinghe and Sarker (2008)	examination of regional trade relations in relation to NAFTA 6 priority agricultural products between 1985–2000	NAFTA countries' trade openness to external countries decreased, while the agreement facilitated internal agricultural trade.
Jayasinghe et al. (2010)	impact of trade costs on US maize seed exports between 1998 and 2004 to 48 countries	Transport costs were the most significant impact on the maize seed trade, so geographical distance is a key factor for the USA.
Hatab et al. (2010)	Egypt's agricultural trading partners from 1994 to 2008	The country's GDP growth has been positive, while GDP per capita growth has had a negative impact on agricultural exports.
Braha et al. (2017)	Albania's agricultural exports between 1996 and 2003 to 46 import partners	Albania's growing population has had a negative impact on agricultural exports. The data showed a high correlation with some countries, which were mainly geographically close to Albania.
Mohammadi et al. (2020)	examination of Iranian pistachio trade with 42 partner countries between 2001 and 2016	Iranian pistachio exports declined significantly after the turn of the millennium. The economic crisis and trade sanctions affecting the country have had a negative impact on pistachio exports.
Abula and Abula (2021)	logistics performance and bilateral trade data of China and 22 countries along the economic corridor of western and central Asia	GDP, population, a mutual neighborhood of the sample countries, and improvement of the performance of international logistics of western and Central Asia have a significant promoting effect on the growth of export of China's agricultural products.
Balogh and Borges Agujar (2022)	investigation of factors affecting the bilateral agricultural trade in Latin America and the Caribbean between 1995 and 2019	Importers' GDP has a greater impact on agricultural trade than those of exporters. Cultural similarities and participation in Southern Common Market stimulate agri-food export. Distance, colonial links, and NAFTA has a negative impact on agricultural export.

NAFTA – North American Free Trade Agreement
Source: Own compilation

MATERIAL AND METHODS

The gravity model is a widely used method in empirical trade analysis, including international agri-food trade. Table 3 provides an overview of articles using a gravity approach to international agricultural trade. The studies cover different groups of agricultural products, ranging from aggregate agricultural trade to individual agri-food products (cotton, maize, rice, pistachios, wine). One group of studies examined international trade in agricultural products from the perspective of a single country group of countries, while the other group focused on world trade in one product.

The impact of RTAs is one of the most important topics in the articles on international agricultural trade. In line with the general literature on the impact of RTAs on trade flows, studies confirm the positive impact of free trade agreements (FTAs) on trade in agricultural products. The coefficients of the market size and trade cost variables are almost invariably significant and have the expected sign based on the literature.

The paper employs international trade data (denominated in USD) for the period 1996–2020 provided by the United Nations (UN) Comtrade database (UNSD 2021). The empirical analysis is based on bilateral trade in maize at the 4-digit level of the Harmonized System (code HS1005).

Over the last three decades, the number of RTAs has increased, and the number of agreements registered by the World Trade Organization (WTO) today exceeds

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300 worldwide (WTO 2020). Within the WTO, RTAs are treaties signed by at least two countries to stimulate the free trade of goods and services across their borders. The agreements also include special internal regulations, which are mandatory for the contracting countries. RTAs can cover all types of trade contractual relations. We rely on the latest developments in the theoretical and empirical gravity literature (Yotov et al. 2016) to specify our econometric model as follows:

$$X_{ij,\,t} = \exp[\pi_{i,\,t} + \chi_{j,\,t} + \beta_1 \ln DIST_{ij} + \beta_2 CNTG_{ij} + \beta_3 LANG_{ij} + \beta_4 CLNY_{ij} + \beta_5 RTA_{ij,\,t}] \times \varepsilon_{ij,\,t} \tag{1}$$

where: $X_{ij,\,t}$ – bilateral trade between partner i and j at time t [exports data, measured in current USD, are from the UN Commodity Trade (Comtrade) Database]; $CNTG_{ij}$, $LANG_{ij}$, and $CLNY_{ij}$ – account for the presence of contiguous borders, common language, and colonial ties between partners i and j, respectively [data on these variables are from CEPII's Distances Database (CEPII 2021)]; $\ln DIST_{ij}$ – logarithm of the bilateral distance between trading partners i and j; $RTA_{ij,\,t}$ – dummy variable capturing the presence of a regional free trade agreement between partners i and j at time t; $\pi_{i,\,t}$ – set of time-varying exporter fixed effects; $\chi_{j,\,t}$ – set of time-varying importer fixed effects, which account for the inward multilateral resistances; $\varepsilon_{ij,\,t}$ – error term; β – estimated coefficients.

To deal with the zero-value trade problem, we employ the Poisson pseudo-maximum-likelihood estimation (PPML) following Santos Silva and Tenreyro (2006).

According to the gravity trade theory, we expect that trade costs are negatively related to the size of the trade. We expect that the distance between partner countries is negatively associated with the size of the exports. The common border, common language, colonial ties, and membership in the same RTA are positively associated with the size of the trade. Table 4 shows the description of variables and the expected signs.

Beyond to standard model specification, we check the robustness of our results by focusing on the following methodological issues separately.

Potential trade diversion effects from domestic sales. Based on Dai et al. (2014) and Anderson and Yotov (2016), we re-estimate our model with a sample that includes both intra-national trade flows and international trade flows. RTAs can lead to a diversion from domestic trade toward international sales, so estimates of the RTA variable based on international trade alone may be biased downwards.

Possible endogeneity of the RTA. Baier and Bergstrand (2007) propose the use of country-pair fixed effects to address the possible endogeneity of RTAs:

$$X_{ij,\,t} = \exp[\pi_{i,\,t} + \chi_{j,\,t} + \mu_{it} + \beta_5 RTA_{ij,\,t}] \times \varepsilon_{ij,\,t} \tag{2}$$

where: μ_{it} – pair-fixed effects.

Due to perfect collinearity, the use of pair-fixed effects does not allow the inclusion of time-invariant standard variables (distance, neighborhood, common language, colonial relationship) in the model, so they are taken out during estimation. Following the work of Yotov et al. (2016), we also remove the fixed effect

Table 4. Description of variables

Variable	Variable description	Variable unit	Expected sign
DIST	physical distance between national capitals for country couples	km	negative
CNTG	common border	dummy variable, value 1 if the trading countries have a common border, 0 otherwise	positive
INTL_CNTG	common border for every *t* year	dummy variable, value 1 if the trading countries have a common border in *t* year, 0 otherwise	positive
LANG	common language	dummy variable, value 1 if the exporting and importing country has a common official language, 0 otherwise	positive
CLNY	colonial relationship	dummy variable, value 1 if there is a colonial relationship between exporter and importer, 0 otherwise	positive
RTA	regional trade agreement	dummy variable, value 1 if the importing country is a member of an RTA, 0 otherwise	positive

Source: CEPII (2021)

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on internal trade from the specification. This means that the value of all internal trade costs is taken as one, while the international fixed effect is estimated relative to the intra-national fixed effect.

The potential reverse causation. To test whether Equation (1) adequately considered the possible 'reverse causal relationship' between trade and RTAs through the country-pair fixed effect, we perform a simple test to assess the 'strict exogeneity' of RTAs. We extend the model by adding a new variable that fixes the future level of RTAs.

$$X_{ij,\,t} = \exp[\pi_{i,\,t} + \chi_{j,\,t} + \mu_{it} + \beta_5 RTA_{ij,\,t} + \beta_6 RTA_{ij,\,t+4}] \times \varepsilon_{ij,\,t} \quad (3)$$

If RTAs are exogenous to trade, the coefficient β_6 associated with the variable $RTA_{ij,\,t+4}$ should not be statistically different from zero.

Possible nonlinearity of RTAs. Considering the possible nonlinear effect of *RTA*, we supplement Equation (4) with different delays of *RTA* variables (maximum 16 years).

$$X_{ij,\,t} = \exp[\pi_{i,\,t} + \chi_{j,\,t} + \mu_{it} + \beta_5 RTA_{ij,\,t} + \beta_6 RTA_{ij,\,t-4} + \beta_7 RTA_{ij,\,t-12} + \beta_8 RTA_{ij,\,t-16}] \times \varepsilon_{ij,\,t} \quad (4)$$

Taking into account the effects of globalization. Finally, we use the method developed by Bergstrand et al. (2015), which considers the possibility that the estimate from Equation (4) may bias upward the effect of *RTA* because they also include effects of globalization such as technology and innovation. Therefore, we add a new group of variables to the model that is related to the borders between partner countries at time *t*.

$$X_{ij,\,t} = \exp[\pi_{i,\,t} + \chi_{j,\,t} + \mu_{it} + \beta_5 RTA_{ij,\,t} + \beta_6 RTA_{ij,\,t-4} + \beta_7 RTA_{ij,\,t-8} + \beta_8 RTA_{ij,\,t-12} + \beta_9 RTA_{ij,\,t-16}] \times \exp[\beta_{10} INTL\_CNTG_{1996} + \beta_{11} INTL\_CNTG_{2000} + \beta_{12} INTL\_CNTG_{2004} + \beta_{13} INTL\_CNTG_{2008} + \beta_{14} INTL\_CNTG_{2012} + \beta_{15} INTL\_CNTG_{2016}] \times \varepsilon_{ij,\,t} \quad (5)$$

where: $INTL\_CNTG_t$ – dummy variable with a value of 1 in the given year if the exporter has a common boundary with the importing country in the given year *t*, otherwise 0.

RESULTS AND DISCUSSION

The results of the gravity model used in the study are presented in Table 5. The columns in the table represent six different models, which are numbered and abbreviated for each model:

– Model 1 (PPML): covers a 'basic' PPML model with the standard explanatory variables;
– Model 2 (INTRA): the values of the dependent variable take into account not only international trade volumes but also domestic trade within each country;
– Model 3 (ENDOG): in order to address the possible endogeneity of the *RTA* variable, the fixed effect per year and per country pair is also included in the estimation;
– Model 4 (REVERSE): in order to control the potential inverse causality, we introduce the variable *RTA* (+4) containing the values of the *RTA* variable shifted by $t + 4$ years;
– Model 5 (NONLIN): the *RTA* variable time delays ($t - 4$, $t - 8$, $t - 12$, and $t - 16$ year delays) are included in the estimation;
– Model 6 (GLOB): we extend the model with variables to consider the temporal dynamics of the effects of globalization.

The geographical distance between the exporting and the importing country reduces the volume of maize trade significantly, with an elasticity (coefficients between 2.622 and 2.617) significantly higher than the estimates found in the literature (which is usually close to 1.000). This can be explained by the fact that maize is a homogeneous commodity with a comparatively low unit value, compared to which logistics and transaction costs represent a relatively high share. Therefore, a strong condition for exporting over longer transport distances is that producers in the exporting country should be able to produce maize more efficiently and at a lower unit cost than those in other maize producing countries which are closer to the destination. However, besides the effect of transport distance, the common border of the importing and exporting countries has no significant effect, which contradicts the results of previous studies (Haq et al. 2013; Ghazalian 2015). The impact of the common language is not significant, while the colonial relationship has a positive impact. We find that RTAs are not significant for bilateral maize trade for all model specifications. These results are in contrast to previous studies (Haq et al. 2013; Ghazalian 2015). There are two reasons for this unexpected RTA effect. First, by the end of the 2010s, the growth in the num-

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Table 5. Estimation results for different models (coefficients and their significance)

Variables	Model 1 (PPML)	Model 2 (INTRA)	Model 3 (ENDOG)	Model 4 (REVERSE)	Model 5 (NONLIN)	Model 6 (GLOB)
ln*DIST*	–2.622***	–2.617***	–	–	–	–
CNTG	0.071	0.072	–	–	–	–
LANG	–0.300	–0.295	–	–	–	–
CLNY	0.973**	0.982**	–	–	–	–
RTA	0.063	0.064	0.121	0.109	–0.079	–0.069
RTA(+4)	–	–	–	0.312**	–	–
RTA(–4)	–	–	–	–	1.246**	1.340***
RTA(–8)	–	–	–	–	0.878***	0.809***
RTA(–12)	–	–	–	–	0.781**	0.746*
RTA(–16)	–	–	–	–	0.198	0.142
$INTL\_CNTG_{1996}$	–	–	–	–	–	0.024
$INTL\_CNTG_{2000}$	–	–	–	–	–	0.088
$INTL\_CNTG_{2004}$	–	–	–	–	–	–0.310
$INTL\_CNTG_{2008}$	–	–	–	–	–	0.206
$INTL\_CNTG_{2012}$	–	–	–	–	–	0.158
$INTL\_CNTG_{2016}$	–	–	–	–	–	0.247
Total RTA effect	–	–	–	–	3.198***	3.148***
N	24 114	24 237	23 450	23 450	23 450	23 450
R^2	0.869	0.869	0.968	0.968	0.968	0.968

*, **, and ***$P < 0.1$, $P < 0.05$, and $P < 0.01$ respectively; ln*DIST* – logarithm of the bilateral distance between trading partners *i* and *j*; *CNTG*, *LANG*, and *CLNY* – account for the presence of contiguous borders, common language, and colonial ties between partners *i* and j, respectively; *RTA* – dummy variable capturing the presence of a regional free trade agreement between partners *i* and *j* at time *t*; *INTL_CNTG* – dummy variable with a value of 1 in the given year if the exporter has a common boundary with the importing country in the given year *t*, otherwise 0

Source: Own calculation

ber of bilateral trade agreements had slowed down significantly. Second, in the same period, world maize trade growth came to an abrupt halt, and the market entered a stagnant phase in the last years of the decade. As trade relations became static, the previously significantly positive RTA effect disappeared by the end of the period.

The second model shows that introducing the effect of domestic trade as a control variable does not significantly change the coefficients of the variables estimated in the first model. This means that the level of international trade in maize is not affected by the transaction costs of domestic trade. Given that this is an agricultural product with inelastic supply and demand, this independence is logical. Countries with an oversupplied, inelastic domestic market are economically forced to export, and countries with an oversupplied, inelastic domestic market are forced to import in any case, regardless of domestic transaction costs.

Model 3 presents the PPML estimation results for the country-pair fixed effect. In this model, the effect of the RTA is still insignificant, but the effective value of the coefficient has doubled. Of course, since it is not significant, the higher actual value has no statistically relevant significance. Still, given the findings of Baier and Bergstrand (2007) on the endogeneity and upward bias of RTAs, the increase in the effective values may suggest that the volume of bilateral maize trade is more affected by traditional informal trade relations than by the existence of formal RTAs between countries in the current year.

To explore the possible impact of a 'reverse causality' between bilateral trade and accession to RTA, we add a four-year lead RTA variable to our specification in Model 4. The lead variable implies the assumption that trade between the two countries has already intensified in the years prior to their joint RTA membership. The results of Model 4 show that future RTA

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Table 6. Comparison of expected and estimated signs of variable coefficients

Variable	Expected sign	Model 1 (PPML)	Model 2 (INTRA)	Model 3 (ENDOG)	Model 4 (REVERSE)	Model 5 (NONLIN)	Model 6 (GLOB)
DIST	negative	negative	negative	N/A	N/A	N/A	N/A
CNTG	positive	NS	NS	N/A	N/A	N/A	N/A
INTL_CNTG	positive	N/A	N/A	N/A	N/A	N/A	NS
LANG	positive	NS	NS	N/A	N/A	N/A	N/A
CLNY	positive	positive	positive	N/A	N/A	N/A	N/A
RTA	positive	NS	NS	NS	NS	NS	NS
RTA (lagged)	positive	N/A	N/A	N/A	N/A	positive	positive
RTA (lead)	positive	N/A	N/A	N/A	positive	N/A	N/A

NS – non significant; N/A – not relevant/not included; *DIST* – bilateral distance between trading partners *i* and *j*; *CNTG*, *LANG*, and *CLNY* – account for the presence of contiguous borders, common language, and colonial ties between partners *i* and *j*, respectively; *RTA* – dummy variable capturing the presence of a regional free trade agreement between partners *i* and *j* at time *t*; *INTL_CNTG* – dummy variable with a value of 1 in the given year if the exporter has a common boundary with the importing country in the given year *t*, otherwise 0

Source: Own compilation; expected signs are based on literature review (see Table 3)

membership has a significant positive effect on current trade between partners. This suggests that trade relations between future members may already develop before membership, with positive effects.

To investigate the persistence over time of the impact of RTA membership agreements, Model 5 includes 4 lagged *RTA* variables with lags of 4, 8, and 12 years. In this lagged model, even the previously insignificant coefficient of the current year *RTA* variable has decreased and even shifted into negative territory. This implies that the current bilateral maize trade intensity is more influenced by the common FTA history than by the existence of a trade agreement between the two countries in the current year. The 4-, 8-, and 12-year lagged *RTA* variables have positive and significant coefficients. This implies that RTAs have their trade-enhancing effect mainly in the years following accession to the agreement. By the second half of the 2010s, the number of parties to trade agreements had not increased significantly, and export volume growth slowed down and then stopped. RTAs as trade promotion instruments, therefore, have time limits. Nevertheless, the overall impact of the RTA (current year and lagged effects combined) is significant and positive, which is fully in line with the literature.

Our next specification (Model 6) follows the methodology of Bergstrand et al. (2015), which includes control variables for the possible effects of globalization. We add a new set of dummy variables to the model to represent the existence of a common border between countries *i* and *j* in each year *t*. We interpret the results for the other *t* years (1996, 2000, 2004, 2008, 2012) relative to 2020. The calculations have two main results. First, the effect of RTAs describes a similar path as in Model 5. Second, the effect of borders describes a non-linear path. The estimation suggests that the overall effect of RTAs remains unchanged when the effects of globalization are taken into account.

Table 6 provides a comparison of expected and estimated signs of variable coefficients. It can be seen that the expectations are mostly fulfilled by the model estimations.

CONCLUSION

The study examines the drivers of international maize trade over the period 1996–2020. Our results show that during a period of radical market growth, the volume of bilateral maize trade was negatively affected by the distance between the two countries. The significant negative impact of distance is consistent with the literature (Disdier and Head 2008; Head and Mayer 2014). However, the high value of the distance coefficient is inconsistent with expectations (Disdier and Head 2008; Yotov 2012) that the impact of transaction costs tends to diminish in highly integrated international markets. However, this discrepancy is not entirely unique, as it is known in the international literature as the 'distance puzzle' problem (Buch et al. 2004). We also consider transaction costs of domestic trade, but the distance puzzle remains in our case. It appears that distance remains an important explanatory factor in explaining trade flows in commodity markets, including maize.

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The predominant role of distance and transport costs may become particularly important in the current energy crisis, which mainly affects Europe but has an impact on supply chains worldwide. Our results warn that even in highly globalized and integrated markets, the increase in transport costs can have a significant impact on bilateral trade relations and, thus, on market structure. The maize market may be particularly vulnerable to disruptions in energy supply and the effects of further increases in energy prices. For countries that are not self-sufficient, the ability to establish bilateral trade links from low geographical distance and at low transaction costs may become a key supply issue. The strong role of geographical distance could provide an incentive for the transport of maize by river and sea in the coming years.

Our findings on the role of RTAs are in line with the results of previous studies: RTAs are generally preceded by a strengthening of bilateral trade relations. There is a mutually positive feedback loop between the level of bilateral trade and RTA membership. However, the establishment of a common RTA membership and its trade-stimulating effects are not immediately visible. Only after a lag of four to eight years do we find a significant positive relationship. The results suggest that the effects of globalization may weaken the effects of RTAs.

From a policy-regulatory perspective, our results highlight three important time constraints in the use of the RTA as an instrument to promote international trade and the free movement of maize. First, RTAs are typically concluded between parties that are already trading with each other; RTAs are usually concluded years (we have verified a 4-year lag in our models) after maize trade between two countries has started. Second, it also takes years for the trade-enhancing effect of RTAs to materialize. Third, there is a time lag before the impact of the agreements once concluded, with no significant trade-enhancing effect being measured after the 15^{th} year following their conclusion.

These constraints should therefore be taken into account in the context of RTAs. Notice that RTAs are most effective when the international market is already in a phase of rapid growth. In a stagnating market without significant natural growth potential, the introduction of RTAs is, therefore, likely to have only a moderate trade expansion effect. However, in a period of rapid market growth, it may be in the interest of individual export-oriented countries to improve their own position through agreements, thereby helping them to maximize their share of international market growth.

The limitations of the research lie mainly in the constraints of the gravity model. The standard model that we follow and its extension to RTAs focuses on a very specific and narrow set of factors. There are many additional drivers and determinants of agricultural production and trade that are ignored by standard gravity models. A possible and novel continuation of our research could be to extend our models with the drivers of maize production efficiency (Tekalign 2019; Adeagbo et al. 2021), furthermore with the conditions and determinants of the international trade of maize (Wondim et al. 2020; Erenstein et al. 2022).

A further limitation of the research is that the period under study was a period of extremely rapid and high market growth. This period of rapid growth obviously cannot be a constant feature of the international maize market. Consequently, our results and findings have limited generalisability to export-import relations in the maize market. This limitation can be overcome by further research over a longer time horizon and by taking into account structural breaks.

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