

RSC 2023/66
Robert Schuman Centre for Advanced Studies
Global Governance Programme

WORKING PAPER

**Do RTAs affect agri-food trade? Evidence
from a meta-analysis**

Sylvanus Kwaku Afesorgbor, Dela-Dem Doe Fiankor,
Binyam Afewerk Demena

European University Institute
Robert Schuman Centre for Advanced Studies
Global Governance Programme

Do RTAs affect agri-food trade? Evidence from a meta-analysis

Sylvanus Kwaku Afesorgbor, Dela-Dem Doe Fiankor, Binyam Afewerk Demena

RSC Working Paper 2023/66

This work is licensed under the [Creative Commons Attribution 4.0 \(CC-BY 4.0\) International license](https://creativecommons.org/licenses/by/4.0/) which governs the terms of access and reuse for this work.

If cited or quoted, reference should be made to the full name of the author(s), editor(s), the title, the series and number, the year and the publisher.

ISSN 1932-1465

© Sylvanus Kwaku Afesorbor, Dela-Dem Doe Fiankor, Binyam Afewerk Demena,
2023

Published in December 2023 by the European University Institute.
Badia Fiesolana, via dei Roccettini 9
I – 50014 San Domenico di Fiesole (FI)

Italy

Views expressed in this publication reflect the opinion of individual author(s) and not those of the European University Institute.

This publication is available in Open Access in Cadmus, the EUI Research Repository:

<https://cadmus.eui.eu>

www.eui.eu



With the support of the
Erasmus+ Programme
of the European Union

The European Commission supports the EUI through the European Union budget. This publication reflects the views only of the author(s), and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Robert Schuman Centre for Advanced Studies

The Robert Schuman Centre for Advanced Studies, created in 1992 and currently directed by Professor Erik Jones, aims to develop inter-disciplinary and comparative research on the major issues facing the process of European integration, European societies and Europe's place in 21st century global politics.

The Centre is home to a large post-doctoral programme and hosts major research programmes, projects and data sets, in addition to a range of working groups and ad hoc initiatives. The research agenda is organised around a set of core themes and is continuously evolving, reflecting the changing agenda of European integration, the expanding membership of the European Union, developments in Europe's neighbourhood and the wider world.

For more information: <http://eui.eu/rscas>

The Policy Paper Series of the Robert Schuman Centre for Advanced Studies complements its Working Papers Series. This series aims to disseminate the views of a person or a group on a particular policy matter, specifically in the field of European integration.

The European University Institute and the Robert Schuman Centre for Advanced Studies are not responsible for the proposals and opinions expressed by the author(s).

The aim of the Robert Schuman Centre for Advanced Studies is to contribute to the public debate by offering views and opinions on matters of general interest.

The EUI and the RSC are not responsible for the opinion expressed by the author(s).

The Global Governance Programme

The Global Governance Programme is one of the flagship programmes of the Robert Schuman Centre. It is a community of outstanding professors and scholars, that produces high quality research and engages with the world of practice through policy dialogue. Established and early-career scholars work on issues of global governance within and beyond academia, focusing on four broad and interdisciplinary areas: Global Economics, Europe in the World, Cultural Pluralism and Global Citizenship.

The Programme also aims to contribute to the fostering of present and future generations of policy and decision makers through its executive training programme: the Academy of Global Governance, where theory and 'real world' experience meet and where leading academics, top-level officials, heads of international organisations and senior executives discuss on topical issues relating to global governance.

For more information: <http://globalgovernanceprogramme.eui.e>

Abstract

Regional trade agreements (RTAs) have experienced significant growth worldwide, leading to an increase in studies assessing their impact on bilateral trade flows. With the availability of disaggregated trade data, numerous studies have examined the influence of these agreements specifically on agri-food trade. However, the results of these studies exhibit heterogeneity, posing challenges for policymakers seeking to understand the effects of RTAs on agri-food trade. To address this issue, we conducted a meta-analysis of 61 studies investigating the effects of various RTAs on agri-food trade. Using funnel asymmetric testing, our analysis reveals the presence of publication bias in the existing literature. By accounting for this bias, we found robust evidence that RTAs positively and significantly promote agri-food trade. Notably, the extent of this effect depends on the depth of economic integration within the RTA, distinguishing between customs unions and free trade agreements, as well as the classification of agri-food products as primary or processed. The ex-post effects of RTAs on agri-food trade are less pronounced when we control for both publication bias and heterogeneity, compared to controlling only for publication bias.

Keywords

RTAs; Agri-food trade; Gravity model; Meta-analysis

JEL classification

F15, F14, Q17, C12

1 Introduction

Regional trade agreements (RTAs) remain one of the most important trade policy tools in the global trading system. According to the recent statistics from the World Trade Organization (WTO), 354 cumulative number of RTAs were in force in 2022.¹ Interestingly, at the multilateral level, agricultural trade liberalization continues to be one of the most debated issues (Martin, 2018) while also occupying a unique position in global trade policy (Bureau et al., 2019). For agricultural trade, RTAs are critical as trade barriers are higher and protectionist policies are more commonly applied on agri-food products than on manufacturing products. Hoekman and Nicita (2011) indicate that both tariff and non-tariff barriers (NTBs) are more restrictive for agricultural compared to non-agricultural products. For instance, the average bound tariff for agricultural products, as of 2013, was 36.5% compared to 11% for industrial products (Bureau and Jean, 2013). Similarly, Grant et al. (2015) identify that sanitary and phytosanitary (SPS) measures within the agricultural sector are more significant and restrictive compared to those in non-agricultural sectors.

Agri-food disputes at the WTO are substantial due to the numerous barriers to agriculture trade (Afe-sorgbor and Beaulieu, 2021; Santana and Jackson, 2012). RTAs are expected to address these disputes and barriers, and thus, have a greater impact on agricultural than on non-agricultural trade. This was confirmed with empirical evidence by Grant and Lambert (2008) who found that RTAs have a greater impact on agricultural than on non-agricultural trade flows. RTAs are said to be important for agricultural trade, but some studies have argued they are not effective since most RTAs fail to include agri-food products in their product coverage. This is due to classifying most agricultural products as sensitive products. For instance, within the North American Free Trade Agreement (NAFTA), following five years of trade liberalization, agricultural trade between the US and Mexico was limited to only nine minor agricultural commodities because of the long phase-out terms for sensitive agricultural products (Hufbauer and Schott, 2005). Indeed, Bureau et al. (2019) state that although the number of RTAs has surged, their role in agricultural trade liberalization has been limited.

Generally, RTAs have been recognized as having widely differing effects on bilateral trade due to their differences in aim, breadth, and scope (Baier et al., 2019). Even within and across RTAs, Baier et al. (2019) indicate that their effects on trade are heterogeneous. There has been an increase in the number of literature on the impact of RTAs on agri-food trade, but the results are highly variable due to increasing heterogeneity in empirical studies. This variation in the literature can be seen from three perspectives: (1) whether the effect of RTAs on agri-food trade are positive or negative, (2) the size (magnitude)

¹<http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx>, accessed August 15, 2022

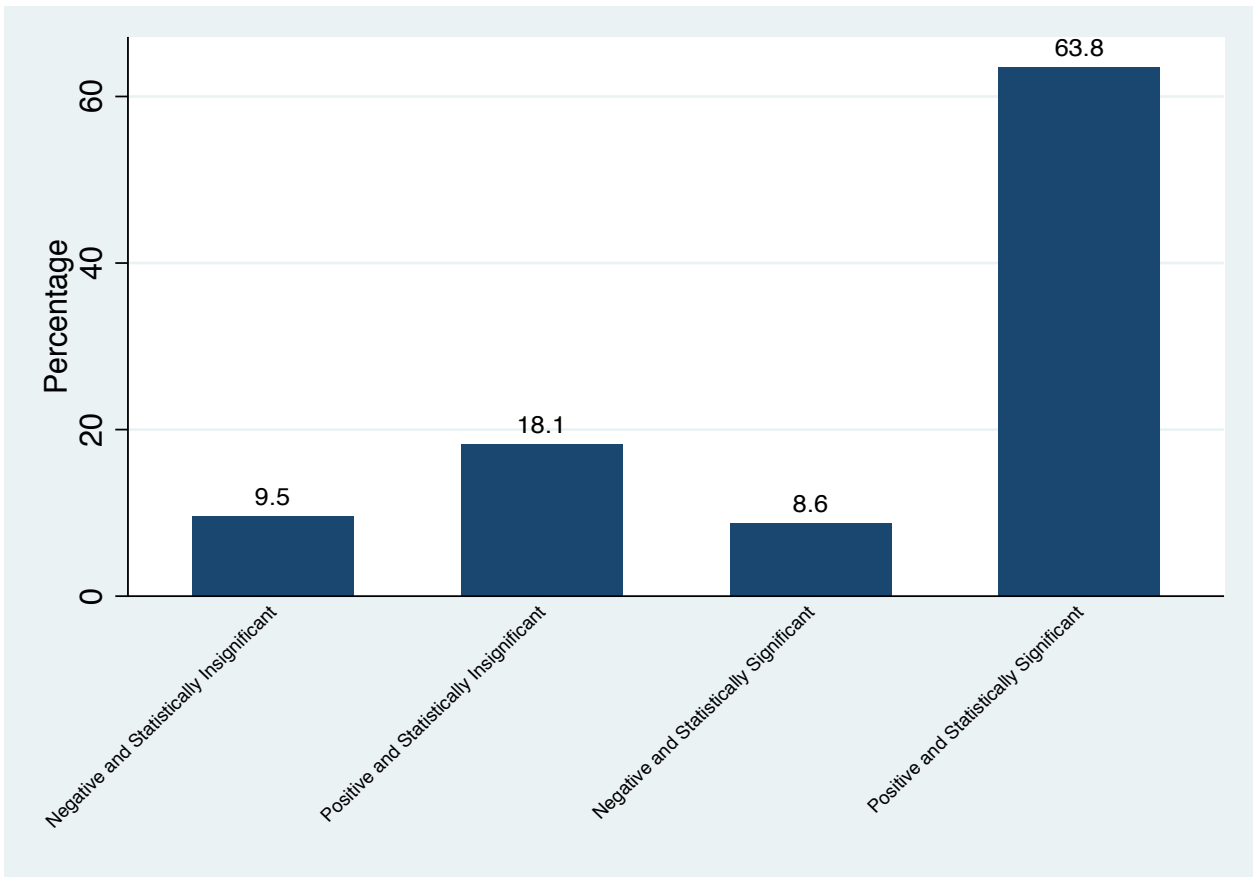


Figure 1: Heterogeneity of RTA effect on agri-food trade

of coefficients, and (3) the statistical significance of the estimated coefficients. Figure 1 illustrates the intricacies found within the mixed results in the literature. In terms of signs, although the majority of studies, such as those by [Grant and Lambert \(2008\)](#), [Grant and Boys \(2012\)](#), and [Jayasinghe and Sarker \(2008\)](#) have consistently found positive effects of RTAs on agri-food trade, there are also a number of studies, such as [Andersson \(2019\)](#), [Vollrath et al. \(2009\)](#) and [Timsina and Culas \(2020b\)](#) that have found negative effects for certain RTAs. The direction of coefficients holds significance, as it could potentially contribute to publication bias. Researchers might hesitate to report a negative RTA effect on trade due to its theoretical implausibility. Consequently, this could lead to a bias in the distribution of effect sizes towards the positive end.

In econometric or regression analyses, the economic significance of an effect size, as reflected by its magnitude, is just as crucial as its statistical significance. The size of an effect provides the economic meaning to the estimated effect. However, the presence of publication bias can distort the effect sizes and their confidence intervals ([Stanley and Doucouliagos, 2012](#)).² Table 1 reveals a notable diversity in the magnitude of the effect sizes (δ) of RTAs on agri-food trade. While a considerable portion of the

²Publication bias is the preference of accepting research papers or choosing results for their statistical significance ([Stanley and Doucouliagos, 2012](#)).

estimates falls within the reasonable range ($0 < \delta < 1$), there remains a substantial proportion (40%) of effect sizes that are both less than 1 and greater than 1. This highlights that the discussion regarding the impact of RTAs encompasses not only the direction (positive or negative) but also the economic significance of the effect.

Table 1: Categorization of the estimate of the RTA-agri-food effect sizes

Range of Effect Sizes	Frequency	Percentage
$-1 < \delta < 0$	397	20.24
$0 < \delta < 1$	1173	59.82
$\delta \geq 1$	391	19.94
Total	1961	100

Notes: δ represents an RTA effect on agri-food trade

The heterogeneity in the literature could emanate from different sources. First, a number of studies have employed data at different levels of disaggregation. These studies have tended to find mixed effects of RTA for disaggregated agri-food products. [Jayasinghe and Sarker \(2008\)](#) analyze the effect of NAFTA on trade for six agri-food product categories. Their results show that NAFTA significantly increased the trade flow of meat, vegetables, grains, and sugar within the regional bloc, while there was no significant effect for the fruits and oilseeds. This heterogeneous effect of NAFTA on different products was also confirmed in a recent study by [Ghazalian \(2017\)](#). He uses bilateral agricultural trade data disaggregated according to the Standard International Trade Classification (SITC) and groups agri-food trade flow into ten categories. [Ghazalian's](#) results also indicate that there are considerable differences across the effect of NAFTA on different categories of agricultural products. Similarly, [Arita et al. \(2017\)](#) also find that RTAs generally have heterogeneous effects; as they find positive and significant effect for only poultry and corn and a non-significant effect for other products, such as beef, pork, fruits, vegetables, soy, nuts, and wheat.

Second, most studies have evaluated the effect of different types and depths of RTAs on agri-food trade. These RTAs have different arrangements in terms of membership, such as South-South, North-South or North-North. There is a wide range of integration levels and scopes in RTAs, which affects the level of trade liberalization. In some RTAs, such as NAFTA, the Association of Southeast Asian Nations (ASEAN) FTA, the Asia-Pacific Economic Cooperation (APEC), and the Southern Africa Development Community (SADC), which are free trade agreements (FTAs), thus trade liberalization is limited to the removal or reduction of tariffs. While RTAs like the Andean Community, the Southern Common Market (MERCOSUR for its Spanish initials), and the Common Market for Eastern and Southern Africa (COMESA) have FTAs plus common external tariffs, which make them customs unions (CUs), with a greater depth of integration. Ultimately, some RTAs, like the European Union (EU), are at the highest

level of integration and are thus expected to have a greater impact on promoting bilateral trade. These different RTA arrangements have different preferences regarding agri-food products, as well as differential impacts on agri-food trade, as was shown by [Bureau and Jean \(2013\)](#).

In addition to variations in integration levels, there is diversity among studies that have explored reciprocal and non-reciprocal trade agreements. Reciprocal agreements involve mutual trade liberalization, where each member reduces trade barriers, whereas non-reciprocal agreements entail one-way trade liberalization. Usually, developed countries unilaterally extend preferential trade agreements (PTAs) to developing countries, exemplified by initiatives like the Generalized System of Preferences (GSP), Everything but Arms (EBA), and the African Growth and Opportunity Act (AGOA).

The diverse range of results can create uncertainty, particularly for policymakers seeking to establish a consensus on the effectiveness of RTAs in promoting agri-food trade. Furthermore, the magnitude of the RTA effect on trade is a point of contention in the literature, with different studies reporting varying effects that can be substantial. The size of this effect is relevant because a substantial effect, exceeding the average estimate of 114% could indicate an upward bias in the estimated effect of an RTA ([Baier et al., 2008](#)). Meta-analysis offers two main advantages according to [Stanley and Doucouliagos \(2012\)](#). First, we can derive an underlying effect size after accounting for publication bias. This is important as [Stanley and Doucouliagos \(2012\)](#) indicate that when publication selection bias is present, the average effect of variables can be distorted. As a second approach, meta-regression analysis (MRA) can be used to explain the variation in empirical results in previous literature, as well as to account for the heterogeneity of study designs. Thus, estimates that are not dependent on the study's design can be derived.

Our paper contributes to the literature in different ways. First, it fills an apparent gap, as there exists no meta-analysis study that synthesizes whether there is any underlying effect of RTAs on agri-food trade. Most meta-analyses of the RTA effect on trade have been performed at the level of aggregated trade flow and not specifically focused on agri-food trade. For example, [Afesorgbor \(2017\)](#) focuses specifically on only African RTAs and aggregate bilateral trade flow, and [Cipollina and Salvatici \(2010\)](#) also focus on different RTAs, but trade was measured at the aggregated level. More closely related papers are by [Li and Beghin \(2012\)](#) and [Santeramo and Lamonaca \(2019\)](#), who focused on agri-food trade; however, their meta-analyses were on the effect of non-tariff measures (NTMs) and other technical barriers to agri-food trade. Second, we differentiate between the effects of RTAs at different levels of integration to reflect the assertion by [Bureau and Jean \(2013\)](#) that the depth of RTA arrangements matters in trade liberalization. Furthermore, this paper differentiates the RTA effect by categorizing agri-food products as primary, processed, and more specific agri-food groups.

2 Literature review

According to [Chaney \(2008\)](#), trade barriers produce more pronounced effects within sectors where the elasticity of substitution is high. Because agricultural products are homogeneous, this is particularly relevant to the sector. [Scoppola et al. \(2018\)](#) argue that the agricultural sector is labeled as a sector with higher elasticity of substitution. Thus, any competitive advantage due to RTAs may affect the market share of trading partners in different markets. Similarly, many studies have also shown that tariffs and NTBs for agricultural products are more restrictive than for non-agricultural goods (see, e.g., [Hoekman and Nicita \(2011\)](#); [Grant et al. \(2015\)](#)). As an example, [Hoekman and Nicita \(2011\)](#) suggest that agricultural sectors in both developing and developed countries are heavily protected where tariffs and NTBs are used to limit agri-food trade.

Assessments of the trade effects of RTAs are usually accompanied by the concepts of trade creation and trade diversion. Trade creation occurs when there is a shift of domestic consumption from high-cost domestic products to low-cost products from a partner country as a result of elimination of trade barriers through an RTA. This results in an improvement in resource allocation and, presumably, positive welfare effects. Conversely, trade diversion refers to a welfare loss which involves a shift of domestic consumption from a low-cost non-member country to a high-cost member country. The majority of prior studies that examined the impact of RTAs primarily concentrated on the trade-creation effect (see, e.g., [Jayasinghe and Sarker \(2008\)](#); [Grant and Lambert \(2008\)](#); [Ghazalian \(2017\)](#))

The principle of non-discrimination in trade is central to the multilateral trade system. However, the General Agreement on Tariffs and Trade (GATT) in Article XXIV allows member states to form free trade areas if they remove substantially all market barriers between them and do not make trade barriers against non-members more restrictive. When trade is non-discriminatory, the home country can export its products provided it has the most efficient producers and then import from low-cost suppliers in a foreign country. This explains, in large part, why bilateral trade flows are heavily influenced by trade agreements; they change this non-discriminatory trade pattern by lowering barriers to trade among member countries ([Mujahid and Kalkuhl, 2016](#)).

The agri-food sector remains the most regulated by SPS measures ([Santeramo and Lamonaca, 2021](#)). For agricultural trade, SPS measures may constitute a pervasive barrier to international trade if used as protectionist policies. The use of SPS measures has been argued to be a subtle way of erecting protectionist policies using food safety concerns as an excuse ([Swinnen and Vandemoortele, 2009](#)). RTAs are critical and expected to facilitate market access for agri-food products among RTA member countries.

Santeramo and Lamonaca (2021) argue that RTAs allow regulatory cooperation through the harmonization or mutual recognition of standards that can promote market access for agri-food products. They also provide robust empirical evidence that SPS measures constitute a trade barrier for non-signatories to RTAs.

3 Empirical strategy

3.1 Data

To conduct a meta-analysis on the RTA effect on agri-food trade, we follow the Meta-Analysis of Economic Research Network (MEAR-Net) guidelines as in Stanley et al. (2013) and Havránek et al. (2020) in searching, collecting, and coding of the relevant empirical studies. The search for relevant studies was conducted between March 2019 and January 2020. The combination of keywords used in identifying relevant literature with the help of the Boolean connectors are as follows: *trade agreement (OR regional trade agreement, free trade agreement, regionalism), agri-food trade (OR agricultural trade, food trade) AND gravity model*. We use the Google Scholar as our main search engine to identify the relevant studies and complement the number of studies using the Web of Science (WoS), AgEcon, and Scopus bibliographic databases. The search produced about approximately 73,000 studies in Google Scholar, indicating a rapid increase in studies and the popularity of the topic within the agricultural and trade literature. Apart from using electronic databases, we also used the forward and backward search approaches by looking at the reference list of the primary studies, as well as recent studies that have cited the primary studies.

Through the screening of the studies, we finally identified 61 studies that met our selection criteria. The first selection criterion was that the papers must be written in English. Second, the papers must be empirical and must use the gravity model as their main econometric tool of analysis. Using only studies that employed the gravity model has the added advantage of making the effect sizes across studies comparable. Cipollina and Salvatici (2010) argue that it is more prudent to restrict the RTA effect to only the gravity model, as using different methodologies could render studies less comparable. In all, the selected studies consisted of 54 number of journal articles and 7 non-journal papers including working papers, conference papers, and reports. The coding and data entry were done by the two authors and a third double-checked the whole entry to ensure the highest scientific standard. From 61 empirical studies that estimated the gravity model, we derived a total of 1961 effect sizes. Table A1 in the online appendix provides information on the list of individual studies analyzed in detail.

3.2 Gravity model

To predict the level of bilateral trade flows induced by an RTA, most of the trade literature employs a (structural) gravity model — which is a basic expenditure equation that indicates how consumers allocate their spending across countries under trade cost constraints. Endogenous to the gravity model is a trade cost term that shows empirically shows how trade barriers modify predicted frictionless trade. Economists augment this trade cost term with a variable that captures the presence or otherwise of a trade agreement. The term is then used to determine whether bilateral exports have increased, decreased, or stagnated as a result of access to the trade area between each pair of RTA member countries before and after the entry into force of an agreement. Since, an RTA is expected to lower trade costs between countries signatory to the agreement, *a priori* expected effect on trade flows is positive. The actual effect is, however, an empirical question and may be asymmetric across countries, heterogeneous across sectors, products, or agreement and vary over time. Since trade agreements arise from negotiations between bilateral pairs and are hence unlikely to be randomly distributed across bilateral pairs, endogeneity is a concern, which different authors have addressed using standard instrumental variable approaches (Egger et al., 2011) or fixed effects or first-differencing (Baier and Bergstrand, 2007).

A standard study examining the effect of RTAs on agri-food trade using the gravity equation specifies an extended variant of the econometric model in the form of Eqn. (1). The specification of the gravity model indicates that trade (X_{ijpt}) of agri-food product p between countries i and j at time t is determined by the market supply potential of i , represented by the GDP (Y_i) of the exporting country, the market demand potential of country j , represented by GDP (Y_j) of the importing country, and the trade cost (T_{ij}) between country i and j . The trade cost is captured by a vector of dyadic variables including distance, tariff, and a set of indicator variables that equal one if i and j share a border, colonial tie, common language, common currency, and GATT/WTO membership. To control for unobserved time-invariant heterogeneity, it is important to include dyadic (α_{ij}), exporter (importer) ($\alpha_{i(j)}$), and product (α_p) fixed effects. Furthermore, to account for external events that are common to all the trading partners, time fixed effects (α_t) are included.

$$X_{ijpt} = \exp[\beta_0 + \beta \ln[Y_{it}(Y_{jt})] + \lambda \ln T_{ijt} + \delta RTA_{ijt} + (1 - \sigma)[P_{it} + \Pi_{jt}] + \alpha_{ij} + \alpha_{i(j)} + \alpha_p + \alpha_t] * \epsilon_{ijpt} \quad (1)$$

Since RTA is our main variable of interest, we isolate it from the vector of the trade cost variables. The RTA coefficient (δ) measures the effect by which bilateral trade between countries in the same regional bloc is higher than countries not in the same regional bloc. Since the studies estimate the δ in log-linear form, we consider the coefficients as semi-elasticity. For economic interpretation of the δ coefficient, it

must be converted using $[(\exp^\delta - 1) * 100\%]$ transformation.

The estimation of the gravity model raises two significant econometric considerations. The first is the presence of the multilateral resistance term (MRT), which includes the inward MRT (P_{it}) and outward MRT (Π_{jt}). MRT signifies that bilateral trade between two countries is influenced not only by bilateral accessibility variables (e.g., distance, borders, common language) but also by the relative geographical positioning of these two countries within the global context. The MRTs are not directly observable to the researcher; however, not properly controlling for this could result in biased results (Baldwin and Taglioni, 2006). Methods used to control for the MRT includes (1) the use of iterative custom nonlinear least squares as proposed by Anderson and van Wincoop (2003), (2) the first order log-linear Taylor expansion by Baier and Bergstrand (2009), and (3) time-varying fixed effects by Feenstra (2016).

The second econometric concern borders on whether studies control for zero flows. Zero flows occur in international trade flow when countries do not trade at all. The use of a log-linearized gravity model excludes zero flows because the log of zero is mathematically undefined and introduces self-selection bias in the gravity model. Properly accounting for zero flows requires using the two-step Heckman selection model by Helpman et al. (2008) or the Poisson pseudo maximum likelihood (PPML) by Santos Silva and Tenreyro (2006). Through the tool of meta-analysis, we examine how controlling for these two major econometric concerns contributes to heterogeneity in the RTA effect on agri-food trade.

In collecting data, we extract the δ coefficients and their standard errors from the individual studies. To account for the presence of outliers in the collected δ coefficients, we winsorize the coefficients and their standard errors at the 5% level. This approach is used in recent meta-analysis study by Zigraiova et al. (2021), which is an objective way to filter out δ coefficients and their standard errors that are considered as outliers. In addition, we also extract additional information on the designs of the studies that account and control for heterogeneity in the studies. Detailed information on all the relevant variables and their descriptive statistics are provided in Table A2 in the online appendix.

3.3 Empirical analysis

3.3.1 FAT-PET analysis

Our primary empirical approach employs meta-analysis. Meta-analysis, as defined by Stanley and Doucouliagos (2012), is a systematic review method that involves the statistical analysis of previously published or reported findings related to a specific hypothesis, particularly when there is substantial variation among the empirical results. They indicate that meta-analysis is already a familiar and conventional tool used in medical research to determine the efficacy on drugs used in randomized clinical

trials. More recently, we have seen a widespread use of the tool of meta-analysis within the field of economics (see, e.g., [Rose and Stanley \(2005\)](#), [Cipollina and Salvatici \(2010\)](#), [Demena and Afesorgbor \(2020\)](#), and [Afesorgbor and Demena \(2022\)](#)). Within the agricultural trade literature, we have seen papers such as [Li and Beghin \(2012\)](#), and [Santeramo and Lamonaca \(2019\)](#) that conducted meta-analyses of the effect of NTMs on agri-food trade. The literature on the effects of RTA on agri-food trade has grown rapidly, with substantial variation and heterogeneity in the results, making meta-analysis an effective tool.

$$\delta_{ks} = \beta_0 + \beta_1 SE_{ks} + \epsilon_{ks} \quad (2)$$

To perform the meta-analysis, we use the funnel asymmetric test (FAT) and the precision effect test (PET) as in Eqn. (2) to determine whether there is an underlying effect beyond publication bias. δ_{ks} is the k^{th} estimated RTA effect on agri-food trade reported by the s^{th} individual study, and SE_{ks} is the standard error of the estimated δ_{ks} , and ϵ_{ks} is the error term. According to [Stanley and Doucouliagos \(2012\)](#), the FAT is used to test the presence or absence of publication bias in the literature. The FAT is represented by β_1 , meaning that the estimated coefficients should be unaffected by the standard errors when there is no publication bias; otherwise, publication bias exists in the literature. Similarly, the PET is captured by the β_0 , which indicates the underlying effect from the empirical studies after accounting for publication bias.

$$t_{ks} = \beta_0 \frac{1}{SE_{ks}} + \beta_1 \quad (3)$$

In estimating Eqn. (2), the error term is not expected to be independent and identically distributed as the variance of the effect and error term would vary from one study to another ([Stanley and Doucouliagos, 2012](#)). Thus, it is obvious that the estimating the equation using ordinary least square (OLS) would produce an inefficient estimator because of heteroskedasticity. To solve the econometric problem, we used the weighted least squares (WLS) approach suggested by [Stanley \(2005\)](#). This approach transforms Eqn. (2) by dividing both left- and right- hand sides by the SE_s , and thus producing Eqn. (3). We weighted all estimations by using the inverse of the standard errors. This transformation converts our dependent variable from the effect sizes (δ_{ks}) into t-values ($t_{ks} = \frac{\delta_{ks}}{SE_{ks}}$).

As highlighted by [Stanley and Doucouliagos \(2012\)](#), when estimating the aforementioned models, there is a valid concern regarding potential dependence among reported estimates, which can lead to autocorrelation among error terms. They indicate that two main types of dependence are within and between dependence. Within dependence arises when the estimates reported in a given study share common attributes due to researchers' idiosyncratic choices about data, methods, and variables ([Stanley and Doucouliagos, 2012](#)). Dealing with the within-dependence requires the use of a fixed effect (FE) estimator in which the reported estimates are clustered within the same study and thus help to produce cluster-robust standard errors.³ Between-dependence arises

³A FE operates under the assumption that the disparities among studies can be attributed solely to within-study variation resulting from sampling fluctuations. In the context of the FE, the effect size from each study is posited to consist

when multiple studies are conducted by the same author. Since the authors are unlikely to contradict their previous results, there is also the likelihood of potential dependence across studies that are related to the same researchers. To minimize these forms of dependence, it is important to use the multi-level mixed (MLM) model as suggested by “[Contrasting conventional with multi-level modeling approaches to meta-analysis: expectation consistency in UK woodland recreation values](#), author=Bateman, Ian J and Jones, Andrew P” (2003) and ?. The MLM approach attempts to model both the within- and between-study dependence (?).⁴

3.3.2 Multivariate meta-analysis

Apart from publication bias, which can be solved using our FAT-PET analysis, heterogeneity among and within primary studies also matters ([Havranek and Irsova, 2017](#)). To account for the heterogeneity in the empirical studies, we also conducted the moderator analysis to explain the variation in the literature. Econometrically, we account for heterogeneity by using Eqn. (4). This equation includes many moderator variables (Z_{hks}) that account for the variation in the design and characteristics of the primary studies.

$$\delta_{ks} = \beta_0 + \beta_1 SE_{ks} + \beta_k \sum_{h=1}^n Z_{hks} + \epsilon_{ks} \quad (4)$$

where h is the number of the moderator variables and Z_{hks} is the specific moderator variable, as listed in Table A2 in the online appendix. It is important to control for heterogeneity because, although many of the studies used the gravity model and thus have comparable effect sizes, there is still extreme variation in many dimensions. First, in the choice of the dependent variable, the studies measured trade using either export, import, or aggregated (sum of both export and import). Second, the studies also measured the trade-creating effects for different RTAs at different depth of integration (such as FTA, PTA, or CU). Third, although we focus on agri-food trade, there are also different product classifications, where some studies estimated the gravity model using total agri-food trade or processed or primary agri-food products. More specifically, the studies also used trade flow at different levels of disaggregation (HS — harmonized system of classification), thus estimating gravity models for more specific products. In our data, we identify six main groups into which we classify the products, namely, (1) animal products, (2) cash crops, (3) grains and oilseeds, (4) fruits and vegetables, (5) prepared foodstuffs, and (6) aggregated products. Product classifications are important, especially as [Santeramo and Lamonaca \(2019\)](#) found that the effect of trade policy variables could be sector- or product-specific. For example, they found that NTMs have trade-distorting effects on seafood products, meat, fruits and vegetables, cereals, and oil seeds, but no adverse effect on fats and oils.

Apart from these, most of the studies differed in terms of the set of standard control variables. A vector of standard control variables includes GDP, distance, tariff and a set of indicator variables that show whether

of two components. Specifically, $\delta_s = \theta + \epsilon$, where θ represents the single population effect size, and ϵ signifies the deviation of the effect size from the true population parameter. Although the true population effect size remains unknown, it is estimated through a weighted average across the individual studies.

⁴This type of data interdependence in an MLM can be accommodated through a two-level model, $t_{ks} = \beta_0 \frac{1}{SE_{ks}} + \beta_1 + \tau_s + \epsilon_{ks}$. Here, the subscript k signifies the regression specification or estimate from study k . Meanwhile, τ_s represents the study-level random effect (random intercept). In this modeling framework, the estimates at level 1 are clustered and nested within studies at level 2 ([Demena and van Bergeijk, 2017](#)).

the trading partners share a border, common language, common currency, and membership in the WTO. The omission of any relevant control variables can bias the RTA effect on agri-food trade. Thus, in accounting for heterogeneity in the design of the studies, we examine whether the inclusion or exclusion of any of these important variables has any systematic influence on the estimated RTA coefficient.

We also account for other dimensions that are not directly related to the gravity model but that can also be potential sources of heterogeneity, such as the data, estimation techniques, and publication characteristics. For data, the studies employed different types of data, such as panel and cross-sectional data, the number of countries (both exporters and importers), and span of years for the data. For estimation characteristics, different studies used varying types of fixed effects, such as dyadic, country, time, and product fixed effects. The inclusion of different fixed effects is important, as they can be used to minimize any endogeneity concerns in the estimation of the gravity model (Baier et al., 2008). For instance, dyadic fixed effects can control for unobserved or non-measurable regulations between the trading partners. The RTA coefficient could be biased without the use of dyadic fixed effects if an unobserved variable is correlated with the RTA variable. For publication characteristics, we also control for different dimensions that relate to whether a study has been peer-reviewed, the number of citations, and the impact factor of the publication outlet of the study.

Our moderator analysis considers 39 potential explanatory variables. The inclusion of all these variables in a single regression could lead to over-specification bias and a multicollinearity problem (Cazachevici et al., 2020; Stanley and Doucouliagos, 2012). To circumvent these problems, we use more recent approaches including Bayesian model averaging (BMA) and frequentist model averaging (FMA) (see, e.g., Cazachevici et al. (2020); Zigrainova et al. (2021)). BMA involves running many regressions using different subsets of the moderator variables (Zigrainova et al., 2021). According to Zigrainova et al., this approach uses a Markov chain Monte Carlo algorithm that approximates the model space and uses the subset of the model space that has the highest posterior model probabilities (PMPs). BMA also reports the posterior mean and posterior standard deviation of the coefficient based on the weighted average of the coefficients from all the estimated models where PMP is used as weight (Zigrainova et al., 2021). Additionally, BMA reports the posterior inclusion probability (PIP), which sums all the PMPs of the models in which the specific variable was included. Based on the values of PIP, Zigrainova et al. (2021) indicate to classify a moderator variable as decisive ($PIP > 0.99$), strong ($0.95 < PIP < 0.99$), positive ($0.75 < PIP < 0.95$), weak ($0.5 < PIP < 0.75$), or irrelevant ($PIP < 0.5$).

Because BMA results only provide information on the relevance of the moderator variables in explaining the heterogeneity, we as well resort to the estimation of FMA as an additional robustness check. FMA results provide point estimates that can be used to quantify the effect of different moderator variables on the RTA effect sizes. As noted by Zigrainova et al. (2021), FMA utilizes Mallor's criteria as weights due to their greater asymptotic optimality.

4 Results and discussions

4.1 FAT-PET results

To determine whether there is any underlying RTA effect on agri-food trade, we first use a naive approach by computing the weighted and unweighted average of the effect sizes. These results are presented in Table 2, which shows that an average effect of 0.440 (weighted) and 0.498 (unweighted), thus, indicating that, on average, an RTA has a positive effect on agri-food trade. The positive influence of RTAs on agri-food trade is consistent with the outcomes of meta-analysis studies conducted by [Cipollina and Salvatici \(2010\)](#) and [Head and Mayer \(2014\)](#), which explored the impact of RTAs on overall trade. It is worth noting that the magnitude of their RTA effects are comparable with our study. Specifically, [Cipollina and Salvatici \(2010\)](#) documented an average effect of 0.59, while [Head and Mayer \(2014\)](#) identified an average effect of 0.5.⁵ However, the presence of publication bias and heterogeneity does not make inferences based on (un)weighted plausible.

Table 2: Simple and weighted means of the RTA effect sizes

	(1)	(2)	(3)	(4)
Method	Effect size	S.E	95% confidence interval	
Simple average effect ^a	0.498[64.5%]	0.015	0.468	0.529
Weighted average effect ^b	0.440 [55.2%]	0.013	0.415	0.466

Notes: *a* represents the arithmetic mean of the estimate of the RTA coefficient, and *b* uses inverse variance as weight. The numbers in the [.] are coefficients converted using $[(\exp^\delta - 1) * 100\%]$ transformation.

We follow the econometric approach by using FAT-PET analysis. To show the robustness of our results, we employ OLS, FE, and MLM to estimate the FAT-PET equation; however, our preferred model is the MLM. The results for the FAT-PET analysis are presented in Table 3. The underlying effect, as captured by PET, shows an RTA effect of 0.284, indicating RTAs across studies, on average, increase agri-food trade by 32.8% $[(\epsilon^{0.284} - 1) * 100\%]$. This indicates that on average, RTAs lead to an increase in agri-food trade by 33% between RTA members compared to non-members.

Our first step in assessing publication bias was to use the funnel plot, as shown in Figure 2. The funnel plot is a scatter plot which shows the relationship between effect sizes (δ_{ks}) and their precision ($\frac{1}{SE(\delta_{ks})}$). The presence of publication bias is graphically confirmed by the funnel plot in Figure 2. Based on [Rose and Stanley \(2005\)](#), if the pictorial view of the funnel plot is not symmetric, then it is a signal that there is publication bias. Empirically, our FAT coefficient also shows a positive and significant effect, indicating the presence of publication bias in the literature. As RTA effects on trade should typically be positive, publication bias in the empirical literature is not surprising. Therefore, researchers finding results contrary to a positive significant RTA effect may have difficulty publishing their work.

⁵The studies by [Cipollina and Salvatici \(2010\)](#) and [Head and Mayer \(2014\)](#) did not conduct a FAT-PET analysis, so we are can only compare the means.

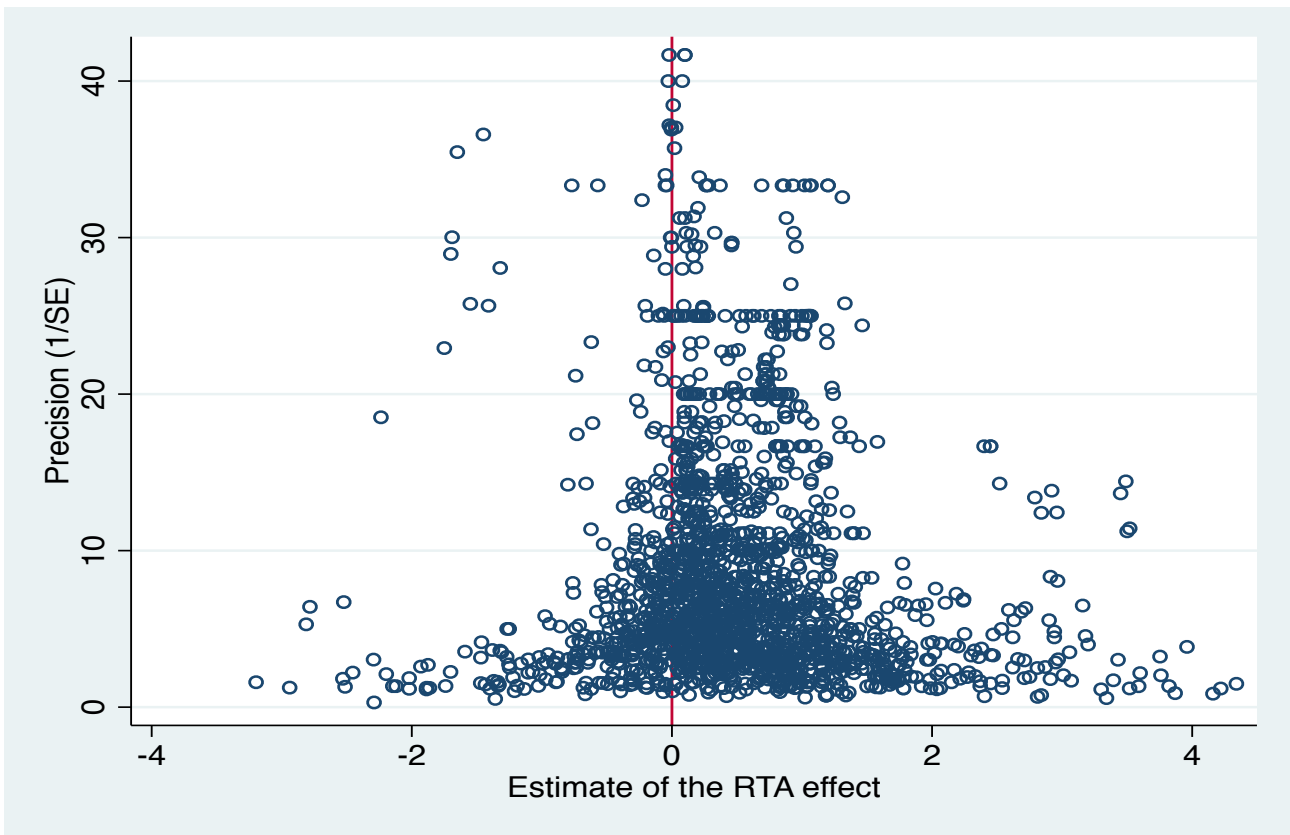


Figure 2: Funnel plot

The FAT-PET analysis in Table 3 utilizes a linear approach. However, recent studies have introduced more advanced robustness checks using non-linear approaches. This is crucial considering that the functional form of meta-average regressions may be non-linear (Gechert et al., 2022). These non-linear approaches are presented in Table 4. First, Ioannidis et al. (2017) develop the weighted average of adequately powered (WAAP) method to demonstrate how statistical power above 80% can correct for publication bias. Second, Andrews and Kasy (2019) propose a selection method that corrects for selective publication bias using the probability of publication as a function of study results. Third, Bom and Rachinger (2019) introduce the kinked model, which incorporates an endogenously determined cut-off expressed as a function of the first-stage estimate of the underlying effect to correct publication bias. Fourth, Furukawa (2019) develops the stem-based method, which calculates the PET by exploiting potential trade-offs between bias and variance. This method is robust to the publication selection process. Fifth, van Aert and van Assen (2021) introduce the p-uniform method, which utilizes the distribution of p-values to identify an underlying effect where the distribution is uniform.

Table 3: Bivariate FAT-PET analysis

	(1)	(2)	(3)
VARIABLES	OLS	FE	MLM
PET (underlying effect)	0.355*** [42.6%] (0.0961)	0.275***[31.6%] (0.0971)	0.284***[32.8%] (0.0209)
FAT (publication bias)	0.769 (0.621)	1.494* (0.874)	1.327*** (0.452)
Observations	1,961	1,961	1,961
Number of studies	61	61	61
R-squared	0.166	0.077	

Notes: The dependent variables are t-values of the associated reported effect sizes. Robust standard errors clustered at the level of studies in parentheses. The numbers in the [.] are coefficients converted using $[(\exp^{\delta} - 1) * 100\%]$ transformation. MLM does not produce an R-square. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The results for these non-linear approaches robustly confirm the linear results in Table 3, and they indicate that there is an effect beyond publication bias. Therefore, compelling evidence is presented indicating that the impact of RTAs on bilateral agri-food trade remains positive and statistically significant, even when utilizing non-linear methods.

Different levels of disaggregation are used to gain a deeper understanding of the impact of RTAs on different groups of agri-food products. First, we classify based on whether an agri-food product is a primary or processed. Scoppola et al. (2018) argue that because of product differentiation and the different levels of substitutability for primary and processed agri-food products, trade policy variables are likely to have a differential effect on them. Hence, we estimate the FAT-PET model for primary products, processed products, and mixed products (when a study estimates the gravity model for primary and processed products) in Table 5. The results show that the RTA effect is positive and significant for both primary and processed products separately, but the

Table 4: Non-Linear Bivariate FAT-PET analysis

	(1)	(2)	(3)	(4)	(5)
	WAAP	Selection model	Kinked model	Stem method	p-uniform
Effects beyond bias	0.399***[49%] (0.071)	0.301***[35.1%] (0.033)	0.355***[42.6%] (0.018)	1.075***[192%] (0.424)	0.432**[54%] (0.248)
Obs.	1961	1961	1961	1961	1961
Studies	61	61	61	61	61

Notes: WAAP is the weighted average of adequately powered. The numbers in the [.] are coefficients converted using $[(\exp^\delta - 1) * 100\%]$ transformation. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

effect is more pronounced for processed products. Specifically, the effect of RTAs on primary products is 31.8% $[(e^{0.276} - 1) * 100\%]$ compared to 67% for processed products. Primary products, according to Scoppola et al. (2018), have higher elasticity of substitution; thus, the effects of trade-promoting policies such as signing trade agreements are expected to have a lower effect compared to processed products that have low elasticity of substitution. They explained that this is primarily due to the differential effect of lower trade costs on the extensive and intensive margins of trade. For primary or homogeneous products, the reduction in trade cost allows an increase in trade at the intensive margins, while the extensive margins effects are weak.

Table 5: Bivariate FAT-PET for different products (MLM estimations)

Variables	Products Categories			Specific Products					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Primary	Processed	Mixed	Aggregate	Animal	Cash Crops	Fruits & Vegetables	Grains & Oilseeds	Prepared Foodstuffs
PET (underlying effect)	0.276***[31.8%] (0.0286)	0.511***[66.7%] (0.0506)	0.191***[21%] (0.0344)	0.306***[35.8%] (0.0290)	0.253***[28.8%] (0.0385)	-0.0247 (0.0458)	0.374***[45.4%] (0.0736)	0.934*** [154.5%] (0.106)	0.109**[11.5%] (0.0552)
FAT (Publication bias)	1.578*** (0.565)	-0.948 (1.374)	1.617*** (0.549)	0.792 (0.740)	1.548*** (0.562)	3.130** (1.298)	0.607 (1.019)	-1.300 (1.055)	1.262 (0.771)
Observations	843	373	745	1,071	366	62	205	68	189
Number of studies	39	17	29	34	24	8	20	11	13

Notes: The dependent variables are t-values of the associated reported effect sizes. Mixed is when the study mixes both primary and processed products while aggregate is when studies measure agri-food trade at an aggregated level. The numbers in the [.] are coefficients converted using $[(\exp^\delta - 1) * 100\%]$ transformation. Robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Breaking down our results for specific products, we observe that the impact of RTAs on the trade of these agri-food products is consistent in terms of direction (positive) and statistical significance, except for cash crops. However, there are variations in the magnitude of the effects among different product groups. In particular, we find that the effects of an RTA on grains and oilseed have a greater positive and significant impact of 155% $[(e^{0.934} - 1) * 100\%]$ compared to other products, such as animal (28.8%), fruits and vegetables (45.3%), and

prepared foodstuffs (11.5%).

In the bivariate analysis, we also assess whether the RTA effects differed based on depth or type of RTA. Table 6 presents the effect on agri-food trade for different types of RTAs. Quantitatively, we find that CUs have a greater impact compared to FTAs. In terms of the size of the effect, CUs promote agri-food trade by, on average, about 379% [$(e^{1.567} - 1) * 100\%$] compared to 22.6% for FTAs. CUs signify a deeper form of integration as they involve having FTAs plus common external tariff. This is consistent with the studies by Ghosh and Yamarik (2004) and Baier et al. (2014) which indicate that the level of integration increases the amount of trade creation. Similarly, for studies that did not differentiate whether an RTA is either an FTA or a CU (others), on average, also find a positive and significant effect. For PTAs, which are non-reciprocal trade agreements, our result shows a negative and insignificant effect. Admassu (2020) emphasizes the ineffectiveness of PTAs, especially when they cause developing countries to channel resources to preference-receiving sectors at the expense of other sectors. This is likely to weaken other sectors not receiving those preferences, and therefore decrease overall trade flows (Admassu, 2020).

Table 6: Bivariate FAT-PET for the depth of RTA (MLM estimations)

	(1)	(2)	(3)	(4)
VARIABLES	PTA	FTA	CU	Others
PET (underlying effect)	-0.0126	0.204***[22.6%]	1.567***[379.2%]	0.324***[38.3%]
	(0.0562)	(0.0262)	(0.0936)	(0.0453)
FAT (Publication bias)	3.473**	1.652***	-7.295***	1.197
	(1.506)	(0.464)	(1.882)	(1.043)
Observations	171	1,261	116	413
Number of studies	10	36	12	26

Notes: The dependent variables are t-values of the associated reported effect sizes. Others is when the study mixes different types of RTAs without explicitly indicating the specific type. The numbers in the [.] are coefficients converted using $[(\exp^{\delta} - 1) * 100\%]$ transformation. Robust standard errors clustered at the level of studies in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.2 Explaining the heterogeneity

In determining which moderator variables can significantly explain the heterogeneity in the RTA effect on agri-food trade, we first present graphical illustration of BMA results in Figure 3. The figure shows all the explanatory variables on the vertical axis, while the horizontal axis shows the individual models and their PMPs. According to Zigrainova et al. (2021), the best models in terms of data fit relative to parsimony are on the left. The blue

and red colors differentiate a whether an explanatory variable in the model has a positive or negative effect on the RTA effect on agri-food trade. The blue color indicates that the variable is included in the model and has a positive effect, while the red color delineates that the variable has a negative effect. A blank cell indicates that the variable is not included in the model and that it has no significant effect on the RTA effect on agri-food trade. Based on the BMA graphical results, we can identify that 9 variables among the vector of moderator variables have significant effects on the RTA effect of agri-food trade.

To determine the strengths and weaknesses of the variables in explaining the variation, the use of PIP (Posterior Inclusion Probability) is necessary. The quantitative results regarding the relevance of the variables, as generated by BMA, are reported in columns (1)-(3) of Table 7. Following the PIP rule of thumb, our results classify three variables as highly relevant determinants of variation, as their PIPs are greater than 0.99. These variables are panel data, export, and tariff. The variable (number of observations) has a strong effect, with its PIP falling between 0.95 and 0.99. Additionally, four variables, namely processed products, custom union, common currency, and lag RTA, have a positive effect, as their PIPs fall between 0.75 and 0.95. The remaining variables either have a weak effect ($0.5 < PIP < 0.75$) or are considered irrelevant ($PIP < 0.5$). Overall, these findings provide insights into the varying strengths and effects of the variables in explaining the observed variation.

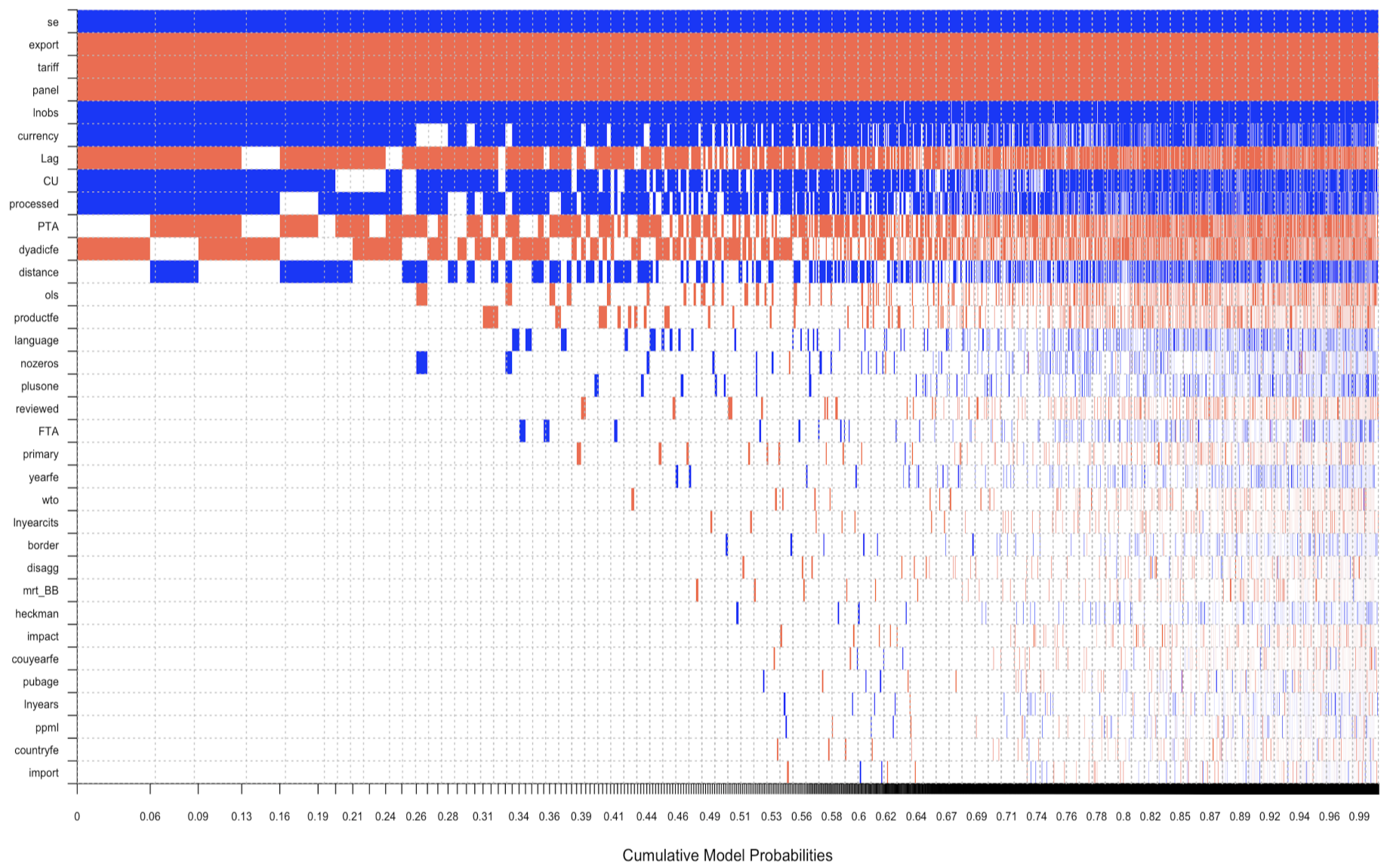


Figure 3: Model inclusion in Bayesian model averaging

In addition, we also present the FMA results in columns (4)-(6) of Table 7. The FMA results display coefficients that reflect how a moderator variable impacts the effect sizes, along with their associated standard errors. Under data characteristics, we find that using panel data is significant, in that, using a panel data in estimating the RTA effect on agri-good trade can lead to a lesser effect by 0.268 compared to studies the used cross-sectional data. This means that using cross-sectional data could lead to an upward bias in the RTA effect on agri-food trade. [Baier and Bergstrand \(2007\)](#) provide a nuance about how the use of cross-sectional data can lead to serious over or under estimated coefficients. They explained that since RTAs are likely to be endogenous, and the use of cross-sectional data in estimating the gravity model could limit the use of fixed effects to minimize any endogeneity concern. Similarly, the number of observations has a strong effect on the effect size, as an a 1 percentage increase in observations is associated with 0.055 increase in the effect size. The number of years and whether a trade data is disaggregated are irrelevant, as their PIPs are less than 0.5.

For the type of product, only processed product has a positive and significant effect while primary product is irrelevant. Based on the FMA coefficient, using processed trade data leads to a higher RTA coefficient by 0.015. The difference in how primary and processed responds to RTA has been confirmed in [Scoppola et al. \(2018\)](#). They argue that trade policy variables such as RTA respond differently to primary and processed products because of the varying level of protection and substitutability. For estimation characteristics, our results indicate the use of fixed effects does not significantly affect the RTA effect on trade. our results indicate that the number of years of data and whether a study used disaggregated trade flows do not contribute significantly to heterogeneity in the RTA effect on agri-food trade. In terms of estimation characteristics, the inclusion of dyadic fixed effects is crucial, as the remaining variables are deemed irrelevant based on their PIPs (Posterior Inclusion Probabilities). Dyadic fixed effects within the gravity model serve to capture unobserved bilateral heterogeneity, including factors such as unmeasurable domestic regulations and the relationship between pairs of countries. [Baier and Bergstrand \(2007\)](#) indicate that adjusting for unobserved time-invariant heterogeneity using dyadic effects has a significant impact on the RTA effect of trade.

We find that the controlling for MRT did not affect the variation in the effect sizes of the gravity model, which was one of the major econometric concerns. This non-significance could be due to the fact that the most studies did not correctly control for MRT by using standard approaches as in [Anderson and van Wincoop \(2003\)](#), [Baier and Bergstrand \(2009\)](#) or [Feenstra \(2016\)](#).⁶ Similarly, we do not find that approaches used to control for zero flows contribute significantly to heterogeneity in the previous studies. Specifically, all variables that are considered as treatments for zero flows have their PIPs less than 0.5.

For the choice of dependent, we see that studies that used export as their dependent variable compared to import are more likely to report less pronounced effect. The direction of trade (i.e., export or import) used in the estimation of the gravity model greatly contributes to explaining heterogeneity. Exports have a negative effect, which means that studies that used exports as their dependent variable would report a lower effect of RTAs on

⁶In Table A2, we can see less than 30% of the studies control for MRT.

Table 7: Bayesian and Frequentist model averaging regression results

	(1)	(2)	(3)	(4)	(5)	(6)
	Bayesian model averaging			Frequentist model averaging		
	Post Mean	Post Std. Dev.	PIP	Coefficient	Std. Error	P-value
Standard error	0.566	0.087	1.000	0.534	0.101	0.000
Panel	-0.315	0.066	0.999	-0.268	0.104	0.010
ln (observations)	0.044	0.011	0.994	0.055	0.015	0.000
ln (years)	0.000	0.004	0.017	-0.015	0.026	0.563
Disaggregated trade	-0.001	0.008	0.020	0.015	0.063	0.812
Primary product	-0.002	0.013	0.044	-0.018	0.040	0.649
Processed product	0.086	0.061	0.735	0.088	0.049	0.073
OLS	-0.014	0.041	0.144	-0.110	0.053	0.037
Dyadic FE	-0.127	0.122	0.565	-0.086	0.079	0.275
Country FE	0.000	0.005	0.017	-0.036	0.051	0.487
Product FE	-0.012	0.036	0.120	-0.116	0.064	0.070
Year FE	0.001	0.010	0.035	0.065	0.053	0.222
MRT -BB	-0.001	0.018	0.020	-0.050	0.128	0.695
Country year FE	0.000	0.006	0.018	0.016	0.052	0.751
Plus one	0.013	0.066	0.054	0.377	0.176	0.033
PPML	0.000	0.006	0.017	0.053	0.061	0.380
Heckman selection	0.001	0.011	0.019	0.145	0.081	0.075
Nozeros	0.006	0.027	0.064	0.133	0.074	0.074
CU	0.169	0.105	0.796	0.173	0.082	0.034
FTA	0.003	0.015	0.047	0.005	0.045	0.918
PTA	-0.101	0.095	0.592	-0.173	0.073	0.017
Lag RTA	-0.237	0.141	0.809	-0.231	0.101	0.023
Currency	0.154	0.088	0.824	0.104	0.070	0.140
Distance	0.082	0.097	0.455	0.118	0.083	0.154
Language	0.009	0.031	0.102	0.081	0.060	0.178
Border	0.001	0.009	0.022	-0.053	0.060	0.374
Export	-0.380	0.039	1.000	-0.338	0.068	0.000
Import	0.000	0.006	0.016	-0.005	0.048	0.910
Tariff	-0.333	0.054	1.000	-0.292	0.077	0.000
WTO	-0.001	0.011	0.028	0.000	0.016	1.000
Publication age	0.000	0.001	0.019	0.000	0.004	1.000
Reviewed	-0.005	0.027	0.053	0.000	0.030	1.000
Impact factor	-0.001	0.022	0.019	0.000	0.066	1.000
Study citation	0.000	0.004	0.024	0.000	0.011	1.000
Intercept	0.396		1.000	0.169	0.213	0.427

Notes: The dependent variables are the effect sizes. PIP is posterior inclusion probability. $PIP > 0.99 \rightarrow$ *decisive*, $0.95 < PIP < 0.99 \rightarrow$ *strong*, $0.75 < PIP < 0.95 \rightarrow$ *positive*, $0.5 < PIP < 0.75 \rightarrow$ *weak* and $PIP < 0.5 \rightarrow$ *irrelevant*

trade. This effect is plausible as exports tend to be under-reported by most countries; imports are more accurate, as countries monitor imports more keenly (Feenstra et al., 1999).

For depth of the economic integration, we find that different forms of trade agreements have a significant effect in explaining the variation in the RTA effect on agri-food trade in tandem with the results in Table 6. Studies that focused on trade agreements that are CUs report a greater positive impact compared to studies that employed trade agreements that are at a lower level of integration. Studies that used PTAs also tend to report lower RTA effects, while an FTA becomes not an important variable in explaining the heterogeneity. These results are intuitive, as FTAs and PTAs have lower depth of integration compared to CUs. This result is consistent with Baier et al. (2014), which indicated that deeper trade agreements, such as CUs have larger effects on trade than FTAs and PTAs. For studies that lagged the RTA variables, we also see this led to a smaller effect size.

For the inclusion of control variables, only common currency and tariff are relevant in explaining the heterogeneity in the RTA effect on trade. Studies that controlled for common currency tends to report greater effects of RTA on agri-food trade. In addition, we find that the inclusion of tariff as additional variable in the gravity model also leads to lower RTA effect. This is also intuitive as tariff reduction accompanies the formation of most RTAs, so including tariff as a control will reduce the magnitude of the RTA effect on trade. Other control variables such as distance, border and WTO membership, do not significantly affect the RTA effect. In terms of publication characteristics, all the variables such as publication age, whether a study is published in a peer-reviewed journal, number of citations and impact factor are not relevant in explaining the heterogeneity in the effect sizes.

Table 8: Meta-effect based on best practices

	(1)	(2)	(3)
	Meta-effect	Lower 95% C.I	Higher 95% CI
Meta-effect based on BMA variables ($PIP > 0.75$)	0.192 [21.2%]	-0.380	0.764
Meta-effect based on BMA variables ($PIP > 0.5$)	0.163 [17.7%]	-0.396	0.721
Meta-effect for BMA ($PIP > 0.5$) and other variables	0.276 [31.8%]	-0.269	0.821

Note: The other variables include distance, country-year FE (controlling for MRT) and PPML (zero flows) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Utilizing the insights from BMA results, we employ an OLS regression to estimate the best practice effect of RTAs on agri-food trade, considering the 8 identified variables that significantly contribute to heterogeneity with $PIP > 0.75$.⁷ Table 8 showcases the outcomes for these 8 moderator variables. To enhance robustness, we incorporate moderator variables with PIPs exceeding 0.5, along with additional relevant moderator variables for estimating the gravity model. The outcomes derived from the best practice approach reveal that, when

⁷The best practice approach is when in the context of multivariate regressions, neither publication bias nor underlying effect can be pinpointed to a single moderator variable, but rather a combination of variables. The selection of the variables is contingent on the personal judgement of the researcher (Stanley and Doucouliagos, 2012).

factoring in publication bias and heterogeneity, the RTA effects on agri-food trade fall within the range of 18 to 32%. This effect is less pronounced compared to considering only publication bias, as observed in the FAT-PET analysis.

5 Conclusion and policy implications

This study provides the first meta-analysis of the effects of RTAs on agri-food trade. In recent years, RTAs have increased exponentially, and we have seen more studies evaluating RTA effects on agri-food trade; thus, a meta-analysis of RTA effects on agri-food trade has become necessary. Furthermore, RTAs and agri-food trade remain prominently on the radars of both developing and developed countries. Because of the heterogeneity across studies, understanding whether RTAs really promote agri-food trade remains a policy-relevant question.

This study conducts a meta-analysis of the existing literature: 61 empirical studies that generated 1961 effect sizes. We first find that RTAs generally have a positive and significant effect on agri-food trade. The ex-post effect of an RTA, after accounting for only publication bias (as determined by the FAT-PET analysis), averages between 32–43%. This means that an RTA increases trade by about these percentages. It is important to note, however, that the effects of RTAs on agri-food trade depend on the depth to which economic integration has been achieved, as CUs tend to have more pronounced effects than RTAs with lower levels of economic integration, such as PTAs and FTAs. Disaggregating the effect between primary and processed agri-food products, we find a greater effect for processed products compared to primary products. Further disaggregating of the RTA effects on specific agri-food products reveals heterogeneous effects. Specifically, we find that the RTA effect on the agri-food trade is most pronounced for grains and oilseeds, followed by fruits and vegetables, animal products, and prepared foodstuffs. Additionally, our findings provide evidence of the presence of publication bias in the empirical literature. This could be due to the presence of conventional views that RTAs are mostly trade-creating.

To explain the heterogeneity in the literature, our study employs two main econometric approaches, BMA for relevance and FMA for the effect of various variables on the RTA effect on agri-food trade. Based on these two methods, our findings show that heterogeneity in the design of previous studies can explain the variation in the literature. We find 8 variables to be key moderator variables in explaining the variation in the results. For data characteristics, we find that the type of data and number of observations are the only significant determinant of effect sizes. In addition, the lagging of RTA, processed agri-food trade product, and the inclusion of control variables such as tariff and common currency, using exports as the outcome variable, are all significant in explaining the heterogeneity. In accounting for heterogeneity and publication bias, our results still show that the effect of RTAs on agri-food trade remains positive and significant. The ex-post effect of an RTA after accounting for publication bias and heterogeneity (based on the best practice approach) averages between 18–32%.

Our study offers policy implications for the agri-food sector, as the results demonstrate the effective utilization

of RTAs in promoting agri-food trade. RTAs can reduce the endemic trade barriers faced by agri-food products in the global market. Therefore, countries should make adequate provisions for the agri-food sector when negotiating trade agreements, that is, the scope and coverage of these trade agreements must be extended to cover agri-food products. A smaller RTA effect for primary products than processed products has implications for developing countries that export primary products primarily. Thus, developing countries must endeavor to add value to their primary agricultural products that are exported to developed countries. Furthermore, there is a necessity to broaden the range of products encompassed by PTAs and GSPs extended by developed countries to developing nations. Finally, our findings underscore the advantage of deeper economic integration for agri-food trade. Consequently, nations should prioritize the enhancement of their economic integration initiatives. This is particularly crucial since many RTAs are currently in the initial stages of economic integration, such as FTAs. There is an increasing necessity for more RTAs to evolve into CUs with common external tariffs, especially to eradicate the lingering rules-of-origin barriers within FTAs.

Considering that our analysis predominantly draws upon empirical studies that emphasize trade creation over trade diversion, we suggest that future meta-analyses should encompass the welfare effects of RTAs by examining both trade creation and trade diversion. Furthermore, we acknowledge the limitation of not being able to directly compare the RTA effect on agricultural trade with manufacturing trade. Therefore, future analyses should also consider incorporating trade in non-agricultural sectors to determine which sector is more significantly impacted by RTAs.

References

- Admassu, S. 2020. The trade creation effects of Africa's reciprocal vis-à-vis non-reciprocal trade agreements. *Empirical Economics*, 59(6), 2717–2730.
- Afesorgbor, S. K. 2017. Revisiting the effect of regional integration on African trade: evidence from meta-analysis and gravity model. *The Journal of International Trade & Economic Development*, 26(2), 133–153.
- Afesorgbor, S. K., and Beaulieu, E. 2021. Role of international politics on agri-food trade: Evidence from US–Canada bilateral relations. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 69(1), 27–35.
- Afesorgbor, S. K., and Demena, B. A. 2022. Trade openness and environmental emissions: Evidence from a meta-analysis. *Environmental and Resource Economics*, 81(2), 287–321.
- Aiello, F., Cardamone, P., and Agostino, M. R. 2010. Evaluating the impact of nonreciprocal trade preferences using gravity models. *Applied Economics*, 42(29), 3745–3760.
- Akhmadi, H. 2017. Assessment the Impact of Asean Free Trade Area (AFTA) on exports of Indonesian agricultural commodity. *AGRARIS: Journal of Agribusiness and Rural Development Research*, 3(1), 9–14.
- Anders, S. M., and Caswell, J. A. 2009. Standards as barriers versus standards as catalysts: assessing the impact of HACCP implementation on US seafood imports. *American Journal of Agricultural Economics*, 91(2), 310–321.
- Anderson, J. E., and van Wincoop, E. 2003. Gravity with gravitas: A solution to the border puzzle. *American Economic Review*, 93(1), 170–192.
- Andersson, A. 2019. The trade effect of private standards. *European Review of Agricultural Economics*, 46(2), 267–290.
- Andrews, I., and Kasy, M. 2019. Identification of and correction for publication bias. *American Economic Review*, 109(8), 2766–94.
- Arita, S., Beckman, J., and Mitchell, L. 2017. Reducing transatlantic barriers on US-EU agri-food trade: what are the possible gains? *Food Policy*, 68, 233–247.
- Baier, S. L., and Bergstrand, J. H. 2007. Do free trade agreements actually increase members' international trade? *Journal of international Economics*, 71(1), 72–95.

- Baier, S. L., and Bergstrand, J. H. 2009. Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation. *Journal of International Economics*, 77(1), 77–85.
- Baier, S. L., Bergstrand, J. H., Egger, P., and McLaughlin, P. A. 2008. Do economic integration agreements actually work? Issues in understanding the causes and consequences of the growth of regionalism. *World Economy*, 31(4), 461–497.
- Baier, S. L., Bergstrand, J. H., and Feng, M. 2014. Economic integration agreements and the margins of international trade. *Journal of International Economics*, 93(2), 339–350.
- Baier, S. L., Yotov, Y. V., and Zylkin, T. 2019. On the widely differing effects of free trade agreements: Lessons from twenty years of trade integration. *Journal of International Economics*, 116, 206–226.
- Baldwin, R., and Taglioni, D. 2006. *Gravity for dummies and dummies for gravity equations*. National bureau of economic research Cambridge, Mass., USA.
- Beckman, J., and Arita, S. 2017. Modeling the interplay between sanitary and phytosanitary measures and tariff-rate quotas under partial trade liberalization. *American Journal of Agricultural Economics*, 99(4), 1078–1095.
- Bektasoglu, B., Engelbert, T., and Brockmeier, M. 2017. The effect of aggregation bias: an NTB-modelling analysis of Turkey’s agro-food trade with the EU. *The World Economy*, 40(10), 2255–2276.
- Bom, P. R., and Rachinger, H. 2019. A kinked meta-regression model for publication bias correction. *Research synthesis methods*, 10(4), 497–514.
- Boughanmi, H., Al Shidhani, J., Mbagha, M., and Kotagama, H. 2010. The effects of regional trade arrangements on agri-food trade: an application of the gravity modeling approach to the Arab Gulf Cooperation Council (GCC) countries. *Review of Middle East economics and finance*, 5(3), 46–62.
- Braha, K., Qineti, A., Cupák, A., and Lazorcáková, E. 2017. Determinants of Albanian agricultural export: The gravity model approach. *AGRIS on-line Papers in Economics and Informatics*, 9(665-2017-1574), 3–21.
- Bureau, J.-C., Guimbard, H., and Jean, S. 2019. Agricultural trade liberalization in the 21st century: Has it done the business? *Journal of Agricultural Economics*, 70(1), 3–25.
- Bureau, J. C., and Jean, S. 2013. *The impact of regional trade agreements on trade in agricultural products* (Tech. Rep.). OECD Publishing.
- Cazachevici, A., Havranek, T., and Horvath, R. 2020. Remittances and economic growth: A meta-analysis. *World Development*, 134, 105021.

- Chaney, T. 2008. Distorted gravity: The intensive and extensive margins of international trade. *American Economic Review*, 98(4), 1707–21.
- Cipollina, M., and Salvatici, L. 2010. Reciprocal trade agreements in gravity models: A meta-analysis. *Review of International Economics*, 18(1), 63–80.
- Contrasting conventional with multi-level modeling approaches to meta-analysis: expectation consistency in UK woodland recreation values, author=Bateman, Ian J and Jones, Andrew P. 2003. *Land Economics*, 79(2), 235–258.
- Delbourg, E., and Dinar, S. 2020. The globalization of virtual water flows: Explaining trade patterns of a scarce resource. *World Development*, 131, 104917.
- Demena, B. A., and Afesorgbor, S. K. 2020. The effect of FDI on environmental emissions: Evidence from a meta-analysis. *Energy Policy*, 138(111192), 1–17.
- Demena, B. A., and van Bergeijk, P. A. 2017. A meta-analysis of FDI and productivity spillovers in developing countries. *Journal of Economic Surveys*, 31(2), 546–571.
- Egger, P., Larch, M., Staub, K. E., and Winkelmann, R. 2011. The trade effects of endogenous preferential trade agreements. *American Economic Journal: Economic Policy*, 3(3), 113–43.
- Ehrich, M., and Mangelsdorf, A. 2018. The role of private standards for manufactured food exports from developing countries. *World Development*, 101, 16–27.
- Fadeyi, O. A., Bahta, T. Y., Ogundeji, A. A., and Willemse, B. J. 2014. Impacts of the SADC free trade agreement on South African agricultural trade. *Outlook on AGRICULTURE*, 43(1), 53–59.
- Feenstra, R. C. 2016. *Advanced international trade, 2e*. Princeton (Princeton University Press).
- Feenstra, R. C., Hai, W., Woo, W. T., and Yao, S. 1999. Discrepancies in international data: An application to China-Hong Kong entrepôt trade. *American Economic Review*, 89(2), 338–343.
- Fiankor, D.-D. D., Flachsbarth, I., Masood, A., and Brümmer, B. 2020. Does GlobalGAP certification promote agrifood exports? *European Review of Agricultural Economics*, 47(1), 247–272.
- Fiankor, D.-D. D., Martínez-Zarzoso, I., and Brümmer, B. 2019. Exports and governance: The role of private voluntary agrifood standards. *Agricultural Economics*, 50(3), 341–352.
- Furukawa, C. 2019. Publication bias under aggregation frictions: Theory, evidence, and a new correction method.
- Gechert, S., Havranek, T., Irsova, Z., and Kolcunova, D. 2022. Measuring capital-labor substitution: The importance of method choices and publication bias. *Review of Economic Dynamics*, 45, 55–82.

- Ghazalian, P. L. 2012. Home bias in primary agricultural and processed food trade: Assessing the effects of national degree of uncertainty aversion. *Journal of Agricultural Economics*, 63(2), 265–290.
- Ghazalian, P. L. 2015. On the magnitude of the geographic distance effect on primary agricultural and processed food trade. *Agribusiness*, 31(2), 148–170.
- Ghazalian, P. L. 2017. The effects of NAFTA/CUSFTA on agricultural trade flows: An empirical investigation. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 65(2), 219–248.
- Ghazalian, P. L., and Cardwell, R. 2010. Did the Uruguay Round Agreement on Agriculture affect trade flows? An empirical investigation for meat commodities. *International Advances in Economic Research*, 16(4), 331–344.
- Ghazalian, P. L., Larue, B., and Gervais, J.-P. 2011. Assessing the implications of regional preferential market access for meat commodities. *Agribusiness*, 27(3), 292–310.
- Ghosh, S., and Yamarik, S. 2004. Does trade creation measure up? A reexamination of the effects of regional trading arrangements. *Economics Letters*, 82(2), 213–219.
- Grant, J. H. 2013. Is the growth of regionalism as significant as the headlines suggest? Lessons from agricultural trade. *Agricultural economics*, 44(1), 93–109.
- Grant, J. H., and Boys, K. A. 2012. Agricultural trade and the GATT/WTO: does membership make a difference? *American Journal of Agricultural Economics*, 94(1), 1–24.
- Grant, J. H., and Lambert, D. M. 2008. Do regional trade agreements increase members' agricultural trade? *American journal of agricultural economics*, 90(3), 765–782.
- Grant, J. H., Peterson, E., and Ramniceanu, R. 2015. Assessing the impact of SPS regulations on US fresh fruit and vegetable exports. *Journal of Agricultural and Resource Economics*, 144–163.
- Haq, Z. U., Meilke, K., and Cranfield, J. 2013. Selection bias in a gravity model of agri-food trade. *European Review of Agricultural Economics*, 40(2), 331–360.
- Havranek, T., and Irsova, Z. 2017. Do borders really slash trade? A meta-analysis. *IMF Economic Review*, 65(2), 365–396.
- Havránek, T., Stanley, T., Doucouliagos, H., Bom, P., Geyer-Klingenberg, J., Iwasaki, I., ... van Aert, R. 2020. Reporting guidelines for meta-analysis in Economics. *Journal of Economic Surveys*, 34(3), 469–475.
- Head, K., and Mayer, T. 2014. Gravity equations: Workhorse, toolkit, and cookbook. In *Handbook of international economics* (Vol. 4, pp. 131–195). Elsevier.

- Hejazi, M., Grant, J. H., and Peterson, E. B. 2018. *Hidden trade costs? Maximum residue limits and US exports of fresh fruits and vegetables* (Tech. Rep.). Center for Agricultural Trade.
- Helpman, E., Melitz, M., and Rubinstein, Y. 2008. Estimating trade flows: Trading partners and trading volumes. *The Quarterly Journal of Economics*, 123(2), 441–487.
- Hndi, B., Maitah, M., and Mustofa, J. 2016. Trade impacts of selected free trade agreements on agriculture: The case of selected North African countries. *Agris on-line Papers in Economics and Informatics*, 8(665-2016-45103), 39–50.
- Hoekman, B., and Nicita, A. 2011. Trade policy, trade costs, and developing country trade. *World Development*, 39(12), 2069–2079.
- Huchet-Bourdon, M., Le Mouel, C., and Peketi, M. 2016. *The impact of regional trade agreements on agrifood trade flows: The role of rules of origin* (Tech. Rep.). HAL archives-ouvertes.
- Hufbauer, G. C., and Schott, J. J. 2005. *NAFTA revisited: Achievements and challenges*. Columbia University Press.
- Ioannidis, J. P. A., Stanley, T. D., and Doucouliagos, H. 2017. The power of bias in economics research. *The Economic Journal*, 127(605), F236-F265.
- Jagdambe, S. 2018. *Impact of AIFTA on Agriculture Trade Creation & Trade Diversion: Gravity Model Analysis* (Tech. Rep.). New Delhi: National Institute for Agriculture Economics and Policy Research.
- Jayasinghe, S., and Sarker, R. 2008. Effects of regional trade agreements on trade in agrifood products: Evidence from gravity modeling using disaggregated data. *Review of Agricultural Economics*, 30(1), 61–81.
- Kareem, O. I. 2019. Necessarily or sufficiently trade-impeding for Africa? The Agri-food safety regulations. *Journal of International Food & Agribusiness Marketing*, 31(3), 308–328.
- Korinek, J., and Melatos, M. 2009. *Trade impacts of selected regional trade agreements in agriculture* (Tech. Rep.). Paris: OECD.
- Lambert, D., and McKoy, S. 2009. Trade creation and diversion effects of preferential trade associations on agricultural and food trade. *Journal of Agricultural Economics*, 60(1), 17–39.
- Lateef, M., Tong, G.-J., and Riaz, M.-U. 2018. Exploring the gravity of agricultural trade in China–Pakistan Free Trade Agreement. *The Chinese Economy*, 51(6), 522–533.
- Li, Y., and Beghin, J. C. 2012. A meta-analysis of estimates of the impact of technical barriers to trade. *Journal of Policy Modeling*, 34, 497–511.

- Martin, W. 2018. A research agenda for international agricultural trade. *Applied Economic Perspectives and Policy*, 40(1), 155–173.
- Mujahid, I., and Kalkuhl, M. 2016. Do trade agreements increase food trade? *The World Economy*, 39(11), 1812–1833.
- Musah, J., Yeboah, O.-A., and Shaik, S. 2020. *Regional trade enhancement by AGOA*. North Carolina.
- Natale, F., Borrello, A., and Motova, A. 2015. Analysis of the determinants of international seafood trade using a gravity model. *Marine Policy*, 60, 98–106.
- Peci, J., and Sanjuán, A. I. 2020. The dual trade impact of non-tariff measures: an empirical assessment of China's pork imports. *European Review of Agricultural Economics*, 47(5), 1716–1739.
- Philippidis, G., Resano-Ezcaray, H., and Sanjuán-López, A. I. 2013. Capturing zero-trade values in gravity equations of trade: an analysis of protectionism in agro-food sectors. *Agricultural Economics*, 44(2), 141–159.
- Pishbahar, E., and Huchet-Bourdon, M. 2008. European Union's preferential trade agreements in agricultural sector: A gravity approach. *Journal of International Agricultural Trade and Development*, 5(1), 93–114.
- Rose, A. K., and Stanley, T. D. 2005. A meta-analysis of the effect of common currencies on international trade. *Journal of Economic Surveys*, 19(3), 347–365.
- Santana, R., and Jackson, L. A. 2012. Identifying non-tariff barriers: Evolution of multilateral instruments and evidence from the disputes (1948- 2011). *World Trade Review*, 11(3), 462–478.
- Santeramo, F. G., and Lamonaca, E. 2019. The effects of non-tariff measures on agri-food trade: A review and meta-analysis of empirical evidence. *Journal of Agricultural Economics*, 70(3), 595–617.
- Santeramo, F. G., and Lamonaca, E. 2021. Standards and regulatory cooperation in regional trade agreements: What the effects on trade? *Applied Economic Perspectives and Policy*.
- Santos Silva, J., and Tenreyro, S. 2006. The log of gravity. *The Review of Economics and Statistics*, 88(4), 641–658.
- Sarker, R., and Jayasinghe, S. 2007. Regional trade agreements and trade in agri-food products: evidence for the European Union from gravity modeling using disaggregated data. *Agricultural Economics*, 37(1), 93–104.
- Scoppola, M., Raimondi, V., and Olper, A. 2018. The impact of EU trade preferences on the extensive and intensive margins of agricultural and food products. *Agricultural Economics*, 49(2), 251–263.

- Serrano, R. I., and Pinilla, V. 2012. The long-run decline in the share of agricultural and food products in international trade: A gravity equation approach to its causes. *Applied Economics*, 44(32), 4199–4210.
- Serrano, R. I., and Pinilla, V. 2016. The declining role of Latin America in global agricultural trade, 1963–2000. *Journal of Latin American Studies*, 48(1), 115–146.
- Sharma, A., Boys, K., and Grant, J. 2019. The bright side of the Generalized System of (Trade) Preferences: Lessons from agricultural trade. *Journal of Agricultural and Resource Economics*, 44(1835-2019-062), 32–61.
- Shepherd, B., and Wilson, N. L. 2013. Product standards and developing country agricultural exports: The case of the European Union. *Food Policy*, 42, 1–10.
- Stack, M. M., Ackrill, R., and Bliss, M. 2019. Sugar trade and the role of historical colonial linkages. *European Review of Agricultural Economics*, 46(1), 79–108.
- Stanley, T. D. 2005. Beyond publication bias. *Journal of Economic Surveys*, 19(3), 309–345.
- Stanley, T. D., and Doucouliagos, H. 2012. *Meta-regression analysis in economics and business*. Routledge.
- Stanley, T. D., Doucouliagos, H., Giles, M., Heckemeyer, J. H., Johnston, R. J., Laroche, P., . . . others 2013. Meta-analysis of economics research reporting guidelines. *Journal of Economic Surveys*, 27(2), 390–394.
- Sun, L., and Reed, M. R. 2010. Impacts of free trade agreements on agricultural trade creation and trade diversion. *American Journal of Agricultural Economics*, 92(5), 1351–1363.
- Swinnen, J. F., and Vandemoortele, T. 2009. Are food safety standards different from other food standards? A political economy perspective. *European Review of Agricultural Economics*, 36(4), 507–523.
- Timsina, K. P., and Culas, R. J. 2020a. Do Free Trade Agreements increase Australian Trade: an application of Poisson Pseudo Maximum Likelihood Estimator? *Journal of East-West Business*, 26(1), 56–80.
- Timsina, K. P., and Culas, R. J. 2020b. Impacts of Australia’s free trade agreements on trade in agricultural products: an aggregative and disaggregative analysis. *Australian Journal of Agricultural and Resource Economics*, 64(3), 889–919.
- Tran, N., Nguyen, A., and Wilson, N. L. 2014. The differential effects of food safety regulations on animal products trade: The case of crustacean product trade. *Agribusiness*, 30(1), 31–45.

- Tran, N., Wilson, N. L., and Anders, S. 2012. Standard harmonization as chasing zero (tolerance limits): the impact of veterinary drug residue standards on crustacean imports in the EU, Japan, and North America. *American Journal of Agricultural Economics*, 94(2), 496–502.
- van Aert, R. C., and van Assen, M. 2021. *Correcting for publication bias in a meta-analysis with the p-uniform* method*.
- Villoria, N. 2012. The effects of China's growth on the food prices and the food exports of other developing countries. *Agricultural Economics*, 43(5), 499–514.
- Vollrath, T. L., Gehlhar, M. J., and Hallahan, C. B. 2009. Bilateral import protection, free trade agreements, and other factors influencing trade flows in agriculture and clothing. *Journal of Agricultural Economics*, 60(2), 298–317.
- Vollrath, T. L., Grant, J. H., and Hallahan, C. 2012. Reciprocal trade agreements: Impacts on US and foreign suppliers in commodity and manufactured food markets. *USDA-ERS Economic Research Report*(138).
- Vollrath, T. L., and Hallahan, C. B. 2012. Reciprocal trade agreements: Impacts on bilateral trade expansion and contraction in the world agricultural marketplace. *Journal of Current Issues in Globalization*, 5(3), 259.
- Webb, M., Gibson, J., and Strutt, A. 2018. The impact of diseases on international beef trade: Market switching and persistent effects. *Food Policy*, 75, 93–108.
- Yang, S., and Martinez Zarzoso, I. 2014. A panel data analysis of trade creation and trade diversion effects: The case of ASEAN–China Free Trade Area. *China Economic Review*, 29, 138–151.
- Yang, S.-H., Reed, M. R., and Saghaian, S. H. 2013. International pork trade and foot-and-mouth disease. *Journal of International Agricultural Trade and Development*, 9(1), 1–23.
- Yanikkaya, H., Kaya, H., and Kocturk, O. M. 2013. The effect of real exchange rates and their volatilities on the selected agricultural commodity exports: A case study on Turkey, 1971-2010. *Agricultural Economics*, 59(5), 235–246.
- Zigraiova, D., Havranek, T., Irsova, Z., and Novak, J. 2021. How puzzling is the forward premium puzzle? A meta-analysis. *European Economic Review*, 134, 103714.

Table A1: Appendix A, List of studies

Count	Author (year)	Pub type	Data start	Data end	No of est.	Mean (E.S.)	Std. Dev.	Min	Max
1	Aiello et al. (2010)	PR	1995	2003	66	0.217	0.552	-0.740	2.064
2	Akhmadi (2017)	PR	2000	2014	1	-0.040	0.000	-0.040	-0.040
3	Anders and Caswell (2009)	PR	1990	2004	8	0.793	0.399	0.331	1.410
4	Andersson (2019)	PR	2009	2013	12	-0.080	0.249	-0.422	0.193
5	Arita et al. (2017)	PR	2010	2012	9	0.527	0.618	-0.200	1.740
6	Beckman and Arita (2017)	PR	2009	2009	11	0.737	0.761	-0.740	2.064
7	Bektasoglu et al. (2017)	PR	1998	2011	12	0.470	0.207	0.073	0.765
8	Boughanmi et al. (2010)	PR	1990	2004	27	0.459	0.965	-0.740	2.064
9	Braha et al. (2017)	PR	1996	2013	8	-0.199	0.568	-0.740	0.688
10	Bureau and Jean (2013)	WP	2002	2009	16	-0.218	0.403	-0.740	0.830
11	Delbourg and Dinar (2020)	PR	1994	2007	2	0.263	0.004	0.260	0.266
12	Ehrich and Mangelsdorf (2018)	PR	2008	2013	32	0.186	0.433	-0.740	1.019
13	Fadeyi et al. (2014)	PR	2000	2011	2	1.562	0.710	1.060	2.064
14	Fiankor et al. (2019)	PR	2010	2015	10	0.465	0.387	0.026	1.066
15	Fiankor et al. (2020)	PR	2010	2015	14	0.764	0.219	0.263	0.889
16	Ghazalian (2012)	PR	1988	2005	62	0.606	0.388	0.120	1.370
17	Ghazalian and Cardwell (2010)	PR	1981	2005	50	0.853	0.120	0.701	1.293
18	Ghazalian (2015)	PR	1988	2011	130	0.794	0.710	-0.740	2.064
19	Ghazalian (2017)	PR	1964	2003	30	0.168	0.227	-0.143	0.613
20	Ghazalian et al. (2011)	PR	2001	2005	30	0.505	0.392	0.094	1.372

Notes: Under publication type, PR denotes peer-reviewed publication while WP denotes working paper. Estimates were generated after winsorization.

Table A1 (continuation): Appendix A, List of studies

Count	Author (year)	Pub type	Data start	Data end	No of est.	Mean (E.S.)	Std. Dev.	Min	Max
21	Grant (2013)	PR	1964	2008	84	0.339	0.351	-0.480	1.440
22	Grant and Boys (2012)	PR	1980	2004	33	0.923	0.545	0.020	1.980
23	Grant and Lambert (2008)	PR	1982	2002	34	0.331	0.245	-0.200	0.790
24	Grant et al. (2015)	PR	1999	2009	7	0.309	0.204	0.120	0.640
25	Haq et al. (2013)	PR	1990	2000	30	0.584	0.417	-0.200	1.175
26	Hejazi et al. (2018)	WP	2013	2014	20	0.721	0.278	0.250	1.080
27	Hndi et al. (2016)	PR	1990	2013	18	0.134	0.606	-0.740	1.554
28	Huchet-Bourdon et al. (2016)	WP	2001	2011	8	0.530	0.406	0.163	1.321
29	Jagdambe (2018)	WP	2005	2014	20	0.804	0.980	-0.740	2.064
30	Jayasinghe and Sarker (2008)	PR	1985	2000	30	0.728	0.815	-0.740	2.064
31	Kareem (2019)	PR	1995	2016	12	0.507	1.399	-0.740	2.064
32	Korinek and Melatos (2009)	WP	1981	2006	12	0.378	0.337	-0.162	1.117
33	Lambert and McKoy (2009)	PR	1995	2004	86	0.779	0.669	-0.620	2.064
34	Lateef et al. (2018)	PR	2001	2014	2	0.581	0.384	0.309	0.852
35	Mujahid and Kalkuhl (2016)	PR	1991	2012	16	0.550	0.598	-0.735	2.064
36	Musah et al. (2020)	WP	2002	2017	4	1.583	0.558	1.044	2.064
37	Natale et al. (2015)	PR	1990	2010	11	0.321	0.106	0.120	0.470
38	Peci and Sanjuán (2020)	PR	2012	2015	7	0.362	0.215	-0.090	0.600
39	Philippidis et al. (2013)	PR	2001	2004	40	0.431	0.589	-0.740	2.064
40	Pishbahar and Huchet-Bourdon (2008)	PR	2000	2004	88	0.565	0.898	-0.740	2.064

Notes: Under publication type, PR denotes peer-reviewed publication while WP denotes working paper. Estimates were generated after winsorization.

Table A1 (continuation): Appendix A, List of studies

Count	Author (year)	Pub type	Data start	Data end	No of est.	Mean(E.S.)	Std. Dev.	Min	Max
41	Sarker and Jayasinghe (2007)	PR	1985	2000	30	0.727	0.649	-0.340	2.064
42	Scoppola et al. (2018)	PR	1990	2006	16	0.107	0.329	-0.570	0.500
43	Serrano and Pinilla (2012)	PR	1963	2000	36	0.446	0.760	-0.740	2.064
44	Serrano and Pinilla (2016)	PR	1963	2000	149	0.408	0.845	-0.740	2.064
45	Sharma et al. (2019)	PR	1962	2010	54	0.063	0.354	-0.740	1.580
46	Shepherd and Wilson (2013)	PR	1995	2003	17	0.150	0.425	-0.638	0.995
47	Stack et al. (2019)	PR	1961	2016	5	0.880	0.495	0.270	1.440
48	Sun and Reed (2010)	PR	1993	2007	36	0.593	0.691	-0.740	2.064
49	Timsina and Culas (2020a)	PR	1996	2017	9	0.154	0.304	-0.289	0.854
50	Timsina and Culas (2020b)	PR	1996	2017	232	0.186	0.600	-0.740	2.064
51	Tran et al. (2012)	PR	2001	2008	8	1.011	0.389	0.698	1.648
52	Tran et al. (2014)	PR	2001	2008	46	1.041	0.842	-0.740	2.064
53	Villoria (2012)	PR	2007	2007	1	0.550	0.000	0.550	0.550
54	Vollrath and Hallahan (2012)	PR	1975	2005	35	0.222	0.244	-0.210	0.820
55	Vollrath et al. (2009)	PR	1995	2005	12	0.012	0.480	-0.740	0.930
56	Vollrath et al. (2012)	WP	1975	2005	123	1.023	0.631	-0.050	2.064
57	Webb et al. (2018)	PR	1996	2013	21	0.444	0.226	0.232	1.064
58	Webb et al. (2018)	PR	2015	2015	2	0.148	0.192	0.012	0.284
59	S. Yang and Martinez Zarzoso (2014)	PR	1995	2010	12	0.196	0.340	-0.330	0.891
60	S.-H. Yang et al. (2013)	PR	1996	2011	5	1.062	0.679	0.240	2.039
61	Yanikkaya et al. (2013)	PR	1971	2010	18	0.193	0.533	-0.740	1.228

Notes: Under publication type, PR denotes peer-reviewed publication while WP denotes working paper. Estimates were generated after winsorization.

Table A2: Definition and descriptive statistics of collected variables ($N = 1961$)

Moderator Variables	Definition	Mean	Std. Dev.
Outcome Characteristics			
Effect size	The partial equilibrium effect size of RTAs	0.502	0.846
Standard error	Standard error of effect size	0.234	0.226
Data Characteristics			
Panel	=1 if data set type is panel (ref. is cross section)	0.929	0.256
No. of years	Logarithm of the number of years of the data used	2.573	1.042
No. of Observations	Logarithm of the number of observations	9.379	2.023
Disaggregated (ref. aggregated)	the structure of the data is disaggregated at sector or product level	0.498	0.500
RTA depth and characteristics (ref. is others)			
CU	=1 if RTA is Customs Union	0.061	0.239
FTA	=1 if RTA is Free Trade Agreement	0.651	0.477
PTA	=1 if RTA is Preferential Trade Area/Agreement	0.087	0.281
Product type (ref. is mixed - both primary & processed)			
Primary	=1 if product is primary	0.430	0.389
Processed	=1 if product is processed	0.033	0.178
Product Characteristics (ref. is Aggregate)			
Animal product	=1 if product is fish, dairy, egg, meat...	0.186	0.495
Cash crop	=1 if product is cash crops, cocoa, coffee, tea, spices	0.190	0.393
Fruit & vegetables	=1 if product is fruit, vegetable, nuts	0.098	0.297
Grains	=1 if product is a cereal/grain & oilseeds	0.035	0.297
Prepared foodstuffs	=1 if Product is prepared foodstuffs	0.098	0.298
Publication Characteristics			
Publication age	The publication year of the study (base, 2006)	7.975	3.937
Reviewed	=1 if published in a peer-reviewed journal	0.899	0.302
Study citations	No. of citations in Google Scholar per age of the study, as of March 2020	2.703	3.229
Impact factor	Recursive journal impact factor from RePEc, as of March 2020	0.087	0.121

Notes: The list of primary studies is presented in the Table A2 in the Appendix.

Table A2 (continuation): Definition and descriptive statistics of collected variables

Moderator Variables	Definition	Mean	Std. Dev.
Estimation Characteristics			
OLS	=1 if estimation method is OLS	0.380	0.486
Dyadic FE	=1 if estimation method is fixed effects	0.159	0.366
Product FE	=1 if product fixed effects are included	0.116	0.317
Year FE	=1 if year fixed effects are included	0.358	0.479
Country FE	=1 if country fixed effects are included	0.291	0.454
Lag RTA	=1 if effect size represents lagged RTA	0.033	0.179
Treatment of multilateral resistance - MRT (ref. is No control for MRT)			
MRT-BB	=1 if the gravity equation accounts for MRT developed by Baier and Bergstrand (2009)	0.028	0.165
Country year FE	=1 if the gravity equation treated MRT using country (product)-year fixed effects	0.275	0.447
Treatment of zero trade flows			
Plusone	=1 if one is added to observations of zero trade flows	0.007	0.086
PPML	=1 if the gravity equation is estimated by the Poisson pseudo maximum likelihood estimator	0.305	0.461
Heckman selection	=1 if Heckman specification proposed by by Helpman, Melitz, and Rubinstein (2008) is used	0.053	0.224
Nozeros	=1 if observations of zero trade flows are deleted/omitted	0.528	0.224
Dependent variable			
Export	=1 if dependent variable is measured with export	0.491	0.500
Import	=1 if dependent variable is measured with import	0.183	0.387
Control variables			
Currency	=1 if the gravity specification controls for shared currency	0.088	0.284
Distance	=1 if the gravity specification controls for distance	0.772	0.419
Language	=1 if the gravity specification controls for shared language	0.557	0.497
Border	=1 if the gravity specification controls for shared common border/adjacency	0.551	0.498
Tariff	=1 if the gravity specification controls for tariff	0.087	0.282
WTO	=1 if the gravity specification controls for WTO	0.181	0.385

Notes: The list of primary studies is presented in the Table A2 in the Online Appendix.

Authors

AFESORGBOR, Sylvanus Kwaku

Department of Food, Agricultural and Resource Economics, University of Guelph, Canada

Robert Schuman Centre, European University Institute, Florence, Italy

safesorg@uoguelph.ca

FIANKOR, Dela-Dem Doe

Agroscope, Swiss Federal Department of Economic Affairs, Switzerland

delademoefiankor@agroscope.admin.ch

DEMENA, Binyam Afewerk

International Institute of Social Studies, Erasmus University Rotterdam, The Netherlands

demena@iss.nl