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Reciprocal Trade Agreements

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Impacts on Bilateral Trade Expansion and Contraction in the World Agricultural Marketplace

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Abstract

The rapid increase in the number of bilateral and regional free-trade agreements since 1995 is a striking development. The proliferation of these agreements has raised questions about whether they have, in fact, opened markets, created trade, promoted economic growth, and/or distorted trade. This study uses panel data from 1975 to 2005 and a gravity framework model to identify the influence of reciprocal trade agreements (RTAs) on bilateral trade in the world agricultural marketplace. A benchmark, Heckman sample-selection and two generalized models, one of which accounts for RTA phase-in effects, are used to gauge the impact on partner trade of mutual as well as asymmetric RTA membership. Empirical results show that RTAs increase agricultural trade between member countries but decrease trade between member and nonmember countries. Interestingly, RTAs were found to be particularly effective at expanding agricultural trade and opening markets in developing countries when developing-country trading partners are part of the same agreement.

Keywords: trade policy, reciprocal trade agreements, bilateral, regional, missing trade, gravity models.

Acknowledgments

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Contents

Also see the recently released ERS report *Selected Trade Agreements and Implications for U.S. Agriculture*, by John Wainio, Mark Gehlhar, and John Dyck (www.ers.usda.gov/publications/err115). This study (ERR-115) uses the computable general equilibrium framework to examine how free trade agreements between ASEAN (Southeast Asia) countries and China and Australia/New Zealand, as well as pending agreements between the United States and Korea, Colombia, and Panama, are likely to affect U.S. agricultural trade. Empirical results find that trade created under these agreements exceeds trade diverted, but that results depend on the specific circumstances of each agreement. The RTA study (ERR-113) uses panel data and econometric models to examine the impact on partner trade in agriculture of all types of bilateral and regional trade agreements in which members agree to open their markets to each other's exports by lowering trade barriers.

Summary

What Is the Issue?

Countries use bilateral/regional trade agreements to increase market access and expand trade in foreign markets. These agreements are called reciprocal trade agreements (RTAs) because members grant special advantages to each other. RTAs include many types of agreements, such as preferential arrangements, free trade agreements, customs unions, and common markets, in which members agree to open their markets to each other's exports by lowering trade barriers. They have become an increasingly prominent feature of the multilateral trading system in recent years, in part, because of stalled global negotiations taking place under the auspices of the World Trade Organization (WTO).

Many observers believe that RTAs deepen market integration and complement efforts by the WTO to liberalize international markets. While acknowledging that RTAs can open up markets, other observers contend that these agreements also distort trade and discriminate against nonmember countries.

Many studies have examined the degree to which RTAs increase trade between member countries. Relatively few, however, have attempted to quantify the extent to which RTAs curtail trade between member and nonmember countries. In this study, ERS empirically examines the bilateral trade expansion/contraction effects of RTAs in the world agricultural marketplace.

What Did the Study Find?

- Model results estimate that RTA membership boosts agricultural trade between member countries, on average, between 34 and 93 percent in the long run.

- The expansion of trade between RTA members typically comes at the expense of trade with nonmember countries. Empirical results show that agricultural trade falls, on average, between 26 and 46 percent in the long run between two countries when one of them does not belong to an RTA to which the other is a member.

- The trade impacts of RTAs grow as producers and consumers adjust to policy-induced changes in market structure and as the implementing provisions of these agreements are phased in over time. Models that account for the cumulative, phase-in effects of RTAs show that, on average, agricultural trade increases 105 percent between two trading partners that belong to the same agreement in the long run but falls 49 percent between an RTA member country and a nonmember trading partner.

- RTAs boost trade in agricultural markets. The percentage increase in partner trade expansion induced by mutual RTA membership exceeds the percentage decline in partner trade characterizing asymmetric RTA membership.

- RTAs are particularly effective at expanding agricultural trade and opening markets in developing countries when both developing-country trading partners are members of the same agreement.

How Was the Study Conducted?

ERS developed econometric models to isolate the impacts of RTAs on bilateral trade in agriculture. Researchers adopted various approaches to control for the influence of the many factors affecting bilateral trade, such as the capacity of suppliers to export, the size of demand in importing countries, transaction costs, and characteristics that induce two countries to trade with each other (e.g., differences in resource endowments). The trade data deployed in model estimations included bilateral trade flows reported by UN Comtrade between 69 countries covering the 1975 to 2005 time frame.

The empirical models identified statistical regularities, controlled for the unique institutional and physical characteristics of each country pair, and allowed for dynamic pricing and RTA phase-in effects. They yielded quantitative estimates of the impacts on partner trade of mutual and asymmetric RTA membership.

Introduction

Trade agreements, whether multilateral, regional, or bilateral in scope, are policy instruments that can increase market efficiency, expand trade, and enhance economic welfare of participant countries. Economists hold a particularly favorable view of the World Trade Organization (WTO), the global organization dealing with the rules of trade between nations, and its predecessor, the General Agreement on Tariffs and Trade (GATT). The GATT/WTO provides an international forum to supervise and liberalize trade worldwide and to ensure that trade flows as freely as possible. The guiding principle is open and free trade enunciated in the WTO's most-favored-nation (MFN) clause. The granting of MFN status means that a country should not discriminate among trading partners.

Acceptable rules and regulations of bilateral/regional trade agreements (RTAs) are identified in Article XXIV of the GATT/WTO. This Article establishes conditions governing cross-border barriers both within bilateral/regional trade agreements and between bilateral/regional-trade-agreement members and nonmembers. One condition eliminates or removes trade barriers on "substantially all the trade" within bilateral/regional trade agreements. Another prohibits member countries from raising trade barriers against non-member countries above their pre-agreement levels.

Since the Annecy Round in 1949, the GATT/WTO has progressively reduced trade barriers in the world marketplace. Agriculture, however, was largely exempt from the trade-liberalizing rules that applied to most products under the GATT; that is, until the Uruguay Round Agricultural Agreement (URAA) in 1994. Still, many countries continue to use a variety of instruments to protect domestic agriculture and to curtail imports of agricultural goods in the post-URAA era. Examples include special safeguards, special and differential treatment for developing countries, relatively high tariffs, and comparatively modest access within tariff-rate quotas.

The Doha Round of the WTO was launched in 2001 with the aim of further opening up agricultural markets and increasing exporter access to both developed and developing country markets. However, no tangible breakthrough has been achieved after 9 years of negotiations. Stalled multilateral talks have provided opportunities for some countries to reduce trade barriers via reciprocal trade agreements (RTAs). These agreements arise when members agree to open their markets to each other's exports by lowering trade barriers. They can take various forms, such as preferential arrangements, free trade agreements, customs unions, and common markets.

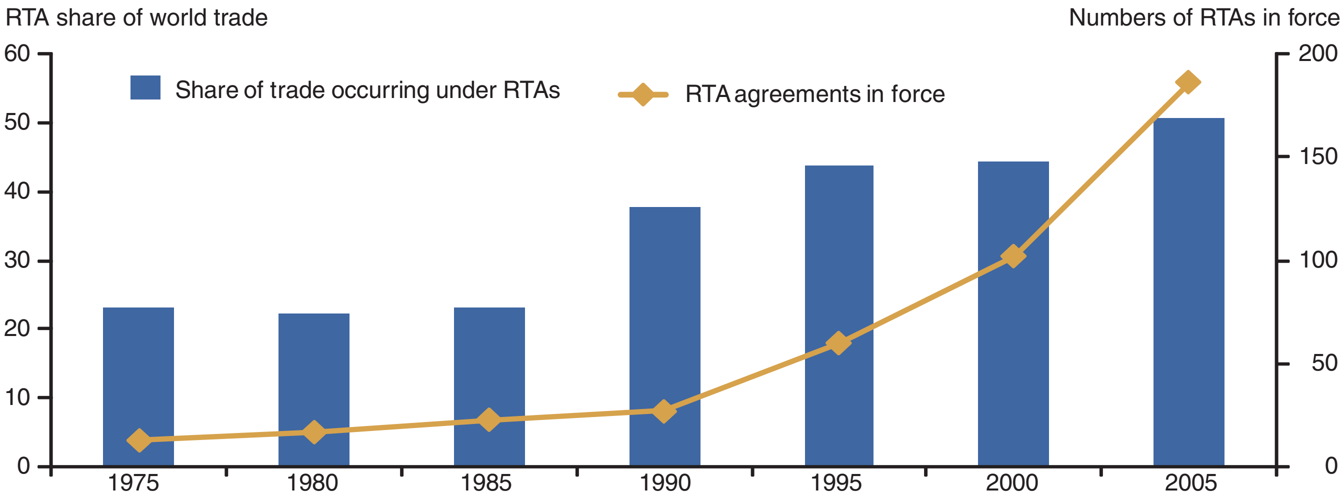
RTAs have become an increasingly prominent feature of the multilateral trading system in recent years. According to the WTO, there were 186 such agreements in force in 2005, up from 50 just prior to the Uruguay Round in 1994, less than 25 in 1985, and just 13 agreements in 1975 (fig. 1).[1] As the number of agreements expanded, the RTA share of world trade rose from 22 percent in 1975 to over 50 percent in 2005.

Some economists believe that RTAs can be powerful forces promoting market liberalization that not only complement, but go beyond, multilateral

[1]According to the WTO's Committee on Regional Trade Agreements (CRTA), as of July 31, 2010, there are a total of 474 bilateral/regional trade agreements in force (World Trade Organization, 2010).

Figure 1

Growth in bilateral/regional trade agreements (RTAs) and their prominence in global markets



Source: USDA, Economic Research Service using Wainio (2006) and Grant and Lambert (2008b)

trade efforts in the WTO to open international markets (Bergsten, 1998). While the WTO has progressively lowered tariffs worldwide, it has made little progress addressing other trade barriers, such as food safety concerns, domestic regulations, and incompatible technical standards. Harmonization of nontariff barriers is a source of trade and welfare gains of RTAs. For example, negotiations leading to the establishment of the North American Free Trade Agreement (NAFTA) addressed many contentious issues inhibiting trade. One result of these discussions was the removal import-licensing requirements for grapes in Mexico. The lifting of these requirements increased U.S. grape exports (Zahniser et al., 2004).

Other economists are less convinced about the positive effects of bilateral/regional trade agreements. They acknowledge that the formation and growth of RTAs can foster trade liberalization, deepen economic integration, and generate economic opportunities, but they also express concerns that these agreements can distort trade, increase discrimination against nonmember countries, and lower overall economic welfare (Bhagwati and Panagariya, 1996; Fiorentino et al., 2006).

Trade theory does not provide a definitive answer as to whether RTAs enhance economic welfare. Increases in partner trade of RTA members may be beneficial whenever production shifts toward the most efficient producers of specific goods within the trading bloc. Consumers are better off in countries belonging to a bilateral/regional trade agreement when they substitute lower priced imported goods from RTA partners for higher priced domestic goods. But while RTAs often increase trade among partner countries, they may also discriminate and favor relatively high-cost member-country suppliers at the expense of more efficient nonmember suppliers.

The impacts of RTAs on the direction and flow of agricultural trade in the world marketplace depend not just upon trade expansion within member blocs but also on trade contraction between RTA and non-RTA members, a byproduct of these agreements. In this study, we empirically examine the effects on bilateral trade of RTAs in agriculture using Viner/Meade's notions of trade creation and trade diversion.

According to Viner (1950), trade creation arises when RTAs induce shifts from domestic to partner country sources of supply. He posits that trade expansion occurs because low-cost products from producers in member countries displace high-cost domestic products. Trade diversion occurs, according to Viner, when RTAs trigger a shift in the source of production from nonmember suppliers to member countries. This happens when bloc partners reorient their imports away from low-cost, nonmember countries toward higher cost, member countries. Meade (1956) elaborated on Viner's production-oriented explanation to include RTA's effects on consumption. Meade points out that even if production in two countries belonging to the same RTA does not change, both countries may gain because lower prices enable their citizens to consume more of the goods for which they express a preference.

Applied research is needed to clarify the economic tradeoffs of bilateral/regional trade agreements. To date, most econometric studies have focused on quantifying the extent to which mutual RTA membership has expanded trade. Relatively few studies have examined how asymmetric RTA membership may also have lowered trade.

In this study, the primary objective of ERS is to empirically examine the impacts of RTAs on bilateral trade in agriculture where restrictive domestic and border policies continue to pose significant impediments to free and open trade. We use the gravity framework and panel data to quantify the degree to which these agreements have affected partner trade, both positively and negatively.

Econometric Models

Clearly, many economic forces besides the establishment of bilateral/regional free-trade agreements shape the direction and volume of trade in the global market. When attempting to empirically isolate the ex-post impact of RTAs, it is, therefore, important to control for the many other determinants affecting partner trade. The gravity framework, which can account for myriad influences, is well suited to identify how these agreements shape cross-border trade.[2] See the appendix for a summary of advances in applied analyses and theoretical linkages underlying the gravity framework.

The gravity framework has been widely used in applied research to assess the RTA impacts on trade between member countries. For example, the following studies have deployed the commonly used RTA dummy variable—defined as equaling one when both the exporter and importer are members of the same agreement, and zero otherwise: Aitken, 1973; Sapir, 2001; Rose and van Wincoop, 2001; Cheng and Wall, 2005; Vollrath et al., 2006; Sandberg et al., 2006; Eicher and Henn, 2009; Subramanian and Wei, 2007; Baier and Bergstrand, 2007; Baier et al., 2008; Grant and Lambert, 2008a.

Soloaga and Winters (2001) developed a model designed to control for relative openness of RTA member countries with the objective of removing the potential bias in intrabloc coefficients. The gravity equations used in their study (as well as in studies by Clarete et al., 2003, and Lambert and McKoy, 2009) include dummy variables to denote mutual RTA membership as well as two dummy variables to control for systematic openness of RTA members, one for the exporter and one for the importer. The *exporter openness* dummy equals one should the exporter be a member of a designated RTA regardless of the status of the importing country. The *importer openness* dummy is defined similarly. It equals one should the importing country belong to an RTA, regardless of the status of the exporting country.

In addition to estimating the intrabloc effects on unidirectional trade flows, applied research has been used to determine whether trade agreements increase two-way trade, advance trade liberalization, and/or lead to market distortions. Eichengreen and Irwin (1995); Bayoumi and Eichengreen (1997); Wei and Frankel (1997); and Ghosh and Yamarik (2004) sought to determine whether individual RTAs were *open* or *closed* trading blocs in models where the dependent variable was the "sum of exports and imports." Rose (2004) and Tomz et al. (2007) addressed whether trade agreements increase the "average value of bilateral trade," using dummy variables to denote mutual membership in these agreements. Vicard (2009) examined whether different types of RTAs (i.e., preferential arrangements, free trade agreements, custom unions, and common markets) affect "total bilateral trade" differentially.

Several studies have developed models designed explicitly to estimate both trade creation and trade diversion. Endoh (1999) developed a model that focused on the European Economic Community, the Latin American Free Trade Association, and the Council of Mutual Economic Assistance. Tang (2005) directed attention to NAFTA, the Closer Economic Relations trade agreement between Australia and New Zealand, and the Association of Southeast Asian Nations (ASEAN) trade agreement. Koo et al. (2006)

[2]One reviewer expressed skepticism that any useful information could be generated from highly aggregate gravity models. Our view is that applied research is needed across numerous levels of aggregation if economists are to provide information about economic relationships that can be helpful to policymakers and can help educate the public. It is important to be able to generalize about the effect of policy instruments, such as bilateral/regional trade agreements, on the patterns of world trade and economic welfare. It is also important to gain insight about the impact of such policy instruments on individual sectors, commodities, periods, and specific agreements. Additional research is needed that focuses attention on the impacts of specific agreements on trade in agriculture, both at the sector level and across individual commodities and also on the impacts of RTAs on exports (imports) of individual countries.

focused attention on the European Union, NAFTA, the ASEAN, and the Andean Community. Magee (2008) and Vollrath et al. (2009) developed generic indexes to quantify overall trade creation and trade diversion. All of the gravity model studies enumerated here, with the exception of Tang and Magee, were estimated using cross-sectional data.[3]

The use of panel, rather than cross-sectional data, is generally preferred, especially in a gravity model incorporating RTA dummy variables. In cross-sectional estimates, the RTA dummies account for everything specific to the bilateral pairs not captured by the invariant fixed effects (e.g., distance) specified in the model. As a result, the RTA dummies in such models do not really isolate the trade-creation and trade-diversion effects. Panel-based models also offer a better opportunity to account for changes (e.g., changes in income) taking place within and between countries over time. Moreover, they generate more efficient parameter estimates. Importantly, they enable the researcher to enrich model specification with fixed effects that mitigate omitted-variable and heterogeneity bias, which more effectively isolates the impacts of RTAs.

In this study, ERS uses panel data and information about mutual and asymmetric RTA membership to estimate gravity models that contain generic RTA indices designed to approximate Viner/Meade's trade creation and trade diversion effects in the global marketplace.[4] The binary mutual-agreement index (*MA*) takes a value of one whenever two countries jointly belong to the same RTA, otherwise *MA* equals zero. The asymmetric-agreement index (*AA*) takes a value of one whenever the exporter is not a member of an RTA to which the importer belongs and zero otherwise. A positive and statistically significant *MA* coefficient indicates that bilateral trade between two countries belonging to the same RTA increases as a result of the removal of tariffs and nontariff restrictions. A negative and significant *AA* coefficient indicates that imports by an RTA member from a nonmember falls as a result of asymmetric membership.

MA and *AA* capture, respectively, bilateral trade expansion and trade contraction in the global marketplace due to RTAs. They do not measure the welfare effects of these agreements, for such effects depend not only on the amount of trade created and diverted but also on relative efficiencies or differences in unit costs. As noted in Palgrave (1987), trade creation increases economic welfare when higher cost domestic sources of supply are replaced by lower cost imports from partner countries that had been constrained by tariffs and nontariff barriers. Trade diversion has a welfare cost when trade-policy discrimination against nonmember countries leads to the replacement of lower cost sources of supply in these countries by higher cost partner country sources.

We estimate two conventional and two generalized gravity models using fixed effects.[5] The conventional models are based upon commonly used benchmark equations as well as Heckman's sample-selection framework. The generalized models are structured to conform to Anderson and van Wincoop's (2003; 2004) analytical framework. The first generalized model is a dummy-intensive fixed-effects model that incorporates exporter-by-time, importer-by-time, and export-import pair dummies. The second includes the same set of fixed effects as the first, but adds RTA phase-in variables to complement the contemporaneous RTA variable. To address the issue of

[3]The trade-diversion variables used in the Tang and Magee studies equal one when *either* country *i* or *j* belongs to an RTA. These dummies depart from Viner's concept of trade diversion in that Viner restricted attention to imports by an RTA member country from a nonmember supplier.

[4]Other studies that have used generic RTA indexes in a panel setting include Rose (2006), Tomz et al. (2007), Subramanian and Wei (2007), Baier and Bergstrand (2007), and Grant and Lambert (2008a). But these indexes have been restricted to portray trade creation, not trade diversion.

[5]A reviewer asked why we never tried random-effects estimation. We did not use this approach, as others have rejected it for theoretical and empirical reasons. Baier et al. (2008) reject using the random-effects model in gravity analyses on conceptual grounds. They point out that unobserved time-invariant variables influence both the presence of RTAs as well as the volume of trade. In the fixed-effects model, these unobservable variables are controlled by using country-pair fixed effects. The problem with the random-effects model is that it assumes zero correlation between these bilateral fixed effects and RTAs. Moreover, Egger (2000) tested for fixed versus random effects after estimating gravity equations with panel data. Using the Hausman test, he found overwhelming empirical evidence for the rejection of random-effects gravity model relative to a fixed-effects model.

heterogeneity of partner trade, we ran the generalized model not only on the global sample of bilateral trade flows between 69 countries but also on eight subsamples, consisting of various combinations of developed and developing countries exporting and importing from each other.

The benchmark model

The basic gravity framework using panel data relates exports by country *i* to country *j* in year *t* to the market size of both countries in year *t* and economic distance or trade costs separating the two countries. In our conventional gravity models, we follow the literature and use Gross Domestic Product (GDP) to quantify market size. The time-varying GDP of the exporting country, (Y_{it}), represents the potential supply of goods from that country. The GDP of the importing country, (Y_{jt}), reflects the potential demand of the goods being traded.[6] Since data on trade costs are not readily available, our basic model includes observable variables to reflect different aspects of bilateral trade costs, namely transportation costs, cultural proximity, and partner trade policies.

Our benchmark gravity equation takes the following form:

$$\ln(X_{ijt}) = \alpha_0 + \gamma_t + \alpha_1 \ln(Y_{it}) + \alpha_2 \ln(Y_{jt}) + \beta_1 \ln(FE_{ijt}) + \beta_2 \ln(DT_{ij}) + \beta_3(CB_{ij}) + \beta_4(LL_{ij}) + \beta_5(LS_{ij}) + \beta_6(CH_{ij}) + \beta_7(TP_{ijt}) + \varepsilon_{ijt} \quad (1)$$

factor endowments are captured by (FE_{ijt}), a measure of exporter-to-importer arable-land/total-labor ratios in year *t*. The indicators for transportation costs include physical distance (DT_{ij}) and two dummy variables to reflect geographical adjacency, (CB_{ij}) which equals 1 when *i* and *j* share a contiguous border and 0 otherwise and landlockedness (LL_{ij}), which equals 1 when either *i* or *j* are landlocked and 0 otherwise. The measures for cultural proximity include language similarity (LS_{ij}) a dummy variable which equals 1 whenever 9 percent or more of the population in both countries share a common language and 0 otherwise;[7] and colonial heritage (CH_{ij}), a dummy variable which equals 1 if two countries have established colonial ties since 1945 and 0 otherwise.[8] Time dummies (γ_t) account for factors common to all countries, including worldwide inflation, increases in trade attributable to globalization, and general shocks affecting the world economy.[9] We include two dummy variables to represent domestic trade policies (TP_{ijt}) in each model type: (1) a dummy variable denoting mutual membership in RTAs (MA_{ijt}), which equals 1 in year *t* when two trading partners are both members of the same bilateral/regional trade agreement and 0 otherwise; and/or (2) a dummy variable denoting asymmetric membership in these agreements (AA_{ijt}), which equals 1 in year *t* when *i* is not a member of an RTA to which *j* belongs and 0 otherwise.[10]

Most gravity models are specified in log-linear terms because of ease of calculation and interpretation. This specification is not, however, without its problems. Taking logarithms often removes observations from the sample because the log of zero is undefined. Omitting zero-flow or missing observations implies that information is lost on the causes of no or very low trade. Moreover, the practice of dropping observations may produce downwardly biased and inconsistent parameter estimates. Consequently, the dependent

[6]A reviewer expressed concern that the GDP variables in our model may induce endogeneity. Baier and Bergstrand (2007) addressed this issue, as well as other possible sources of endogeneity, in gravity equations. They contend that while GDP is a function of total exports and total imports, the inclusion of country *i*'s income and country *j*'s income as independent variables in gravity equations is not a likely cause of endogeneity because each importer has many suppliers and each exporter sends its goods to many destination markets.

[7]The 9-percent threshold serves to denote the level at which the ability to communicate is viewed as not imposing substantial transaction costs.

[8]Rose identifies four types of dummy variables that can be used to control for colonial heritage in gravity models: (1) a binary variable which is unity if *i* and *j* were ever colonies after 1945 with the same colonizer, (2) a binary variable which is unity if *i* is a colony of *j* at time *t* or vice versa, (3) a binary variable which is unity if *i* ever colonized *j* or vice versa, and (4) a binary variable is unity if *i* and *j* remained part of the same nation during the sample. We arbitrarily chose the first type of binary variable to depict colonial heritage in our models.

[9]The $\gamma_t = 1$ when year is equal to *t* and 0 otherwise, where *t* = 1975, 1980,……2005.

[10]The two RTA dummies were constructed using "full-year" enforcement, with full year referring to at least 8 months of agreement implementation.

variable in gravity models estimated using samples where no trade is recorded for some export-to-import partners is no longer bilateral trade; rather, it is bilateral trade contingent on the existence of trading relationships.

The Heckman model

Heckman's (1979) sample-selection model offers a theoretically sound and econometrically elegant way to include zero flows in models of bilateral trade (Linders and de Groot, 2006).[11] The sample selection gravity model allows for the correlation between (1) the joint decision of whether *i* chooses to export to *j* and *j* chooses to import from *i* and (2) the amount, if any, of unidirectional trade between *i* and *j*. In other words, this model accounts for the relationship between *expected profitability* and *conditional expected trade*. A "selection equation" is used to incorporate the binary decision of whether or not to trade based on expected profitability. Then, an "outcome equation" determines the volume of bilateral trade.

[11]Linders and de Groot (2006) investigated other methods for dealing with zero-trade flows, including various extensions of Tobit estimation, truncated regression, probit regression, and replacement of zero flows with arbitrary numbers. They found the sample-selection model econometrically preferable to these alternative approaches.

To circumvent problems associated with zero trade flows, we estimate conventional gravity equations using Heckman's sample-selection framework. We chose the maximum likelihood estimator (MLE), as research has shown that MLE is preferred over the Heckman two-step estimator to jointly estimate the selection and outcome equations (Martin and Pham, 2008).

Formally, the Heckman model distinguishes between the selection and outcome processes:

$$s^*_{ij} = \mathbf{z}_{ij}\boldsymbol{\delta} + v_{ij} \text{ (selection mechanism)}$$

$$y_{ij} = \boldsymbol{x}_{ij}\boldsymbol{\beta} + \mu_{ij} \text{ (outcome mechanism)}$$

where z_{ij} and x_{ij} are the vectors of variables affecting the selection and outcome mechanisms, respectively; s^* is the underlying latent variable representing the decision whether to trade (s is observed to be 1 if trade occurs and 0 otherwise); y is the log of trade when trade occurs ($s = 1$); and the μ and v errors are assumed to be jointly normally distributed with correlation ρ.

The expected value of y, given that it is observed, is

$$E[\, y \mid \boldsymbol{s} = 1\,] = \boldsymbol{x\beta} + \rho\lambda(\boldsymbol{z\delta})$$

where $\lambda(\mathbf{z}\boldsymbol{\delta})$ is the Inverse Mills Ratio (IMR).[12]

[12]OLS parameter estimates are likely to be downwardly biased and inconsistent should incidental truncation arise ($\rho \neq 0$). In such situations, the OLS regression is misspecified as it excludes the Inverse Mills Ratio as an independent variable. As a result, OLS coefficients are attenuated (i.e., biased toward zero) and the error variance (σ^2_U) is underestimated.

The first set of covariates in the sample-selection model determine the probability of whether the two countries engage in trade. The second set of covariates determines the intensity of bilateral trade, conditional on the existence of a trade relationship. MLE estimation allows for the probability of trade and the size of potential trade to be explained jointly.

Our sample-selection model for bilateral agricultural trade is specified as follows:

The selection equation

$$s_{ijt}^{*} = \delta_0 + \delta_t + \delta_1 \ln(Y_{it}) + \delta_2 \ln(Y_{jt}) + \delta_3(FE_{ijt}) + \delta_4 \ln(D_{ij}) + \delta_5 \ln(CB_{ij})$$
$$+ \delta_6 \ln(LL_{ij}) + \delta_7 \ln(LS_{ij}) + \delta_8(CH_{ij}) + \delta_9(TP_{ijt}) + \upsilon_{ijt} \quad (2)$$

where

$s_{ijt} = 1$ if $s_{ijt}^{*} > 0$

$s_{ijt} = 0$ if $s_{ijt}^{*} \leq 0$

The outcome equation[13]

$$\ln(X_{ijt}^{*}) = \beta_0 + \beta_t + \beta_1 \ln(Y_{it}) + \beta_2 \ln(Y_{jt}) + + \beta_3 \ln(FE_{ijt}) + \beta_4 \ln(D_{ij}) + \beta_5 \ln(CB_{ij})$$
$$+ \beta_6 \ln(LL_{ij}) + \beta_7(CH_{ij}) + \beta_8(TP_{ijt}) + \mu_{ijt} \quad (3)$$

where

(μ_{ijt}, ν_{ijt}) – bivariate normal $\left[0,0,1,\sigma_{\upsilon}^{2},\rho_{\nu\mu}\right]$

The generalized gravity models

Anderson and van Wincoop (AvW) developed a generalized gravity model in which prices play a central equilibrating role. Baier and Bergstrand (BB) extended the AvW framework to a panel setting and estimated models that controlled for the effects of changes in multilateral prices through time via the use of exporter-by-time and importer-by-time fixed effects. BB's generalized gravity model also controls for partner heterogeneity via the use of exporter-to-importer fixed effects. These country-pair dummies account for the whole host of time-invariant dyadic determinants (e.g., the special relationship established between Japan and the United States) that mutually affect the volume of trade for each partner pair. Baier and Bergstrand also developed a model that includes RTA lags in order to gauge the phase-in effects of these agreements on member countries' trade over time.

Generalized gravity models address the concerns about proper specification identified earlier. Following AvW and BB, the first such model we estimate is as follows:

$$\ln(X_{ijt}) = \alpha_0 + \gamma_{ij} + \gamma_{it} + \gamma_{jt} + \beta_1(TP_{ijt}) + \varepsilon_{ijt} \quad (4)$$

where γ_{it} denotes exporter-by-time fixed effects, γ_{jt} signifies importer-by-time fixed effects, and γ_{ij} represents exporter-to-importer fixed effects.[14] Equation (4) does not include either $\ln(Y_{it})$ or $\ln(Y_{it})$, as these regressors are absorbed by γ_{it} and γ_{it}, respectively. Similarly, specific dyadic variables, such as distance and contiguity, are absorbed by γ_{ij}.

Equation (4) overcomes many of the shortcomings of conventional gravity models. The country-by-time dummies control for multilateral resistances à

[13]To circumvent a possible identification problem, we followed common practice by excluding an exogenous variable in the outcome equation that is included in the selection equation. One reviewer was critical of our choice of dropping the language-similarity variable. However, William Greene of New York University informed us (in personal communication) that the identification restriction was not only a "nonissue" when using the MLE, but that, if a restriction was imposed, it made little difference which variable was chosen to exclude from the selection equation. Moreover, we did not estimate the Heckman model in two stages, but rather simultaneously, using maximum likelihood estimator.

[14]$\gamma_{it} = 1$ for exporter i in year t and 0 otherwise, $\gamma_{it} = 1$ for importer j in year t and 0 otherwise, and $\gamma_{ij} = 1$ for country i exporting to importer j and 0 otherwise (where $i = 1, 2, \ldots 69$, $j = 1, 2, \ldots 69$, and $t = 1975, 1980 \ldots 2005$). A reviewer asked why γ_{ij} did not pick up the effects of RTAs. The answer is that the TP indices, unlike the country-pair fixed effects, are not invariant over the 31-year time period of the analysis. MA and AA are coded dynamically to account for the changing composition of RTAs through time as countries join/depart from the specific agreements.

la AvW. These dummies not only account for time-varying export and import price indexes that influence bilateral trading decisions but also sweep away country-specific time-varying effects, such as shifts in domestic policies and macroeconomic shocks. The exporter-to-importer dummies provide a way to more thoroughly control for cultural and physical heterogeneity among country pairs than determinants commonly found in conventional gravity models (e.g., distance, contiguity, language similarity, and common colonial heritage).

RTAs typically take time to mature. Their effects on trade cannot, therefore, be completely captured with binary variables using the date RTAs entered into force. The second generalized model we estimate follows Baier and Bergstrand's framework and incorporates lagged RTA dummies to address this problem. This framework includes the same set of fixed effects as the first, but adds RTA phase-in variables.

Our RTA phase-in model includes contemporaneous and lagged RTA dummy variables at 5 and 10 years as follows:

$$\ln(X_{ijt}) = \alpha_0 + \gamma_{ij} + \gamma_{it} + \gamma_{jt} + \varphi_1(TP_{ij,t}) + \varphi_2(TP_{ij,t-5}) + \varphi_3(TP_{ij,t-10}) + \varepsilon_{ijt} \quad (5)$$

The lagged variables mitigate measurement errors typically found in gravity models that include RTAs as explanatory variables that arise due to the inability of contemporaneous 0-1 dummy variables to account for the phase-in effects of these agreements. In recognition of heterogeneity characterizing partner trade, equation (5) was run not only on the global sample of 69 countries trading with each other but also on 8 subsamples, categorized by various combinations of high and low per capita incomes of the exporting and importing countries.

Data

The panel dataset developed for this study includes bilateral trade flows for agriculture among 69 countries at 5-year intervals beginning in 1975 and ending in 2005.[15] Most, but not all, countries export (import) to every other country. However, 20 percent of the cells are "missing" in the agricultural trade matrix.[16] Summary statistics for the variables in the panel dataset are shown in table 1.

Bilateral trade data were obtained from the United Nations Commodity Trade Statistics (UN Statistical Office, 2008) database, *UN Comtrade*, the primary international data source for partner- and product-specific trade that includes most countries and products. The WTO's definition of agriculture is used to quantify total agricultural trade. Distances between capital cities and/or the major commercial center closest to partner countries were calculated using the great circle method obtained from USDA's Agricultural Research Service. Data on colonial heritage and landlockedness were obtained from Andrew Rose's (2006) website. Data on language similarity were obtained from the Centre d'Etudes Prospectives et d'Informations Internationales (2005) website. Information about arable land was obtained from the United Nations Food and Agricultural Organization's (2008) FAOSTAT database. Data on bilateral/regional trade agreements and their date of entry into force were compiled by scrutinizing multiple sources, including Oh (2006) and the WTO website (see box, "MA and AA: Two Generic RTA Variables Denoting Bilateral Trade Policies"). All other data were obtained from *World Development Indicators* (see World Bank, 2005).

[15]The 69 countries include Algeria, Argentina, Australia, Austria, Bangladesh, Belgium-Luxembourg, Brazil, Cameroon, Canada, Chile, China (mainland), Colombia, Costa Rica, Denmark, Dominican Republic, Egypt, El Salvador, Finland, France, Germany, Ghana, Greece, Guatemala, Honduras, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Ivory Coast, Jamaica, Japan, Jordan, Kenya, Malaysia, Mexico, Morocco, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Pakistan, Panama, Paraguay Philippines, Poland, Portugal, Saudi Arabia, Senegal, Singapore, South African Customs Union (Botswana, Lesotho, Namibia, South Africa, and Swaziland), South Korea, Spain, Sri Lanka, Sweden, Switzerland, Taiwan, Thailand, Trinidad-Tobago, Tunisia, Turkey, United Kingdom, United States, Uruguay, Venezuela, and Zambia.

[16]We assume that empty cells are due to no trade actually having taken place.

MA and AA: Two Generic RTA Variables Denoting Bilateral Trade Policies

The proliferation of bilateral and regional trade agreements in recent years raises the question of the impact of this phenomenon on agricultural trade in the world marketplace. This study examines this phenomenon and gauges its impact on partner trade in cases of mutual and asymmetric RTA membership using two generic indices. The MA index is used to quantify trade creation characterizing joint RTA membership. The AA index is used to compute trade diversion typifying partners when the exporter is not a member of an RTA to which the importer belongs. Both measures incorporate the following reciprocal preferential arrangements, free-trade agreements, customs unions, and common markets: Andean Community, Association of Southeast Asian Nations (ASEAN), Australia-Singapore Agreement, Australia-Thailand Agreement, Canada-Chile Agreement, Canada-Costa Rica Agreement, Canada-Israel Agreement, Canada-U.S. Free Trade Agreement, Caribbean Community, Central American Common Market, Chile-Costa Rica Agreement, Chile-El Salvador Agreement, Chile-Israel Agreement, China-Hong Kong Agreement, Closer Economic Relations, Common Market for Eastern and Southern Africa, European Free Trade Agreement (EFTA), EFTA-Chile Agreement, EFTA-Israel Agreement, EFTA-Jordan Agreement, EFTA-Mexico Agreement, EFTA-Morocco Agreement, EFTA-Poland Agreement, EFTA-Singapore Agreement, EFTA-Turkey Agreement, European Union (EU), EU-Algeria Agreement, EU-Chile Agreement, EU-Egypt Agreement, EU-Israel Agreement, EU-Jordan Agreement, EU-Mexico Agreement, EU-Morocco Agreement, EU-Norway Agreement, EU-South Africa Agreement, EU-Switzerland Agreement, EU-Tunisia Agreement, EU-Turkey Agreement, G-3 Free Trade Area, Greater Arab Free Trade Area, Gulf Cooperation Council, India-Sri Lanka Agreement, Japan-Singapore Agreement, Latin American Integration Agreement, MERCOSUR, MERCOSUR-Chile Agreement, Mexico-Chile Agreement, Mexico-Costa Rica Agreement, Mexico-El Salvador Agreement, Mexico-Guatemala Agreement, Mexico-Honduras Agreement, Mexico-Israel Agreement, Mexico-Japan Agreement, Mexico-Nicaragua Agreement, New Zealand-Singapore Agreement, North American Free Trade Agreement, Panama-El Salvador Agreement, Poland-Israel Agreement, Poland-Turkey Agreement, South African Development Community, South Asian Preferential Trade Arrangement, Turkey-Israel Agreement, U.S.-Australia Free Trade Agreement, U.S.-Chile Free Trade Agreement, U.S.-Israel Free Trade Agreement, U.S.-Jordan Free Trade Agreement, and the U.S.-Singapore Free Trade Agreement.

Table 1
Summary statistics for variables in panel dataset

Variable	Statistics[1]	Description
X_{ij}	70 (355)	Agricultural trade between *i* and *j* (millions of U.S. dollars)
Y_i	377 (1,105)	GDP of exporter *i* (billions of U.S. dollars)
Y_j	370 (1,105)	GDP of importer *j* (billions of U.S. dollars)
FE_{ij}	24 (218)	Relative factor endowment: exporter-to-importer 0.1 hectare of arable land per worker in the total labor force
DT_{ij}	7,910 (4,666)	Kilometers between exporter *i*'s and importer *j*'s major commercial cities
CB_{ij}	0.03 (0.17)	Dummy: both countries share a common border
LL_{ij}	0.13 (0.33)	Dummy: if either or both countries are landlocked
LS_{ij}	0.21 (0.41)	Dummy: 9 percent or more of the population in both countries share a common language
CH_{ij}	0.01 (0.12)	Dummy: existence of a colonial linkage after 1945
MA_{ij}	0.10 (0.29)	Dummy: mutual RTA membership
AA_{ij}	0.90 (0.30)	Dummy: asymmetric RTA membership
No. of observations	25,931	

[1]Sample means with standard deviations in parentheses.

Source: USDA, Economic Research Service.

Empirical Findings

Econometric results for the applied gravity models are displayed in tables 2-6. Tables 2 and 3 contain the statistical results for the benchmark and Heckman models. Table 4 presents empirical findings from the dummy-intensive generalized model focused on contemporaneous RTA variables. Tables 5 and 6 exhibit statistics from the generalized-gravity models that account for contemporaneous as well as RTA phase-in effects.

Findings from benchmark and Heckman models

Most parameter estimates in the benchmark models and the Heckman output equations are similar in magnitude and statistical significance (tables 2 and 3).[17] The size of the exporter-income, importer-income, and factor-endowment coefficients are virtually identical and statistically significant at the 0.01 level in both models. Interestingly, the absolute size of the coefficients for distance, common border, landlockedness, and colonial heritage are slightly smaller in the benchmark than in the Heckman models. By contrast, the *MA* and *AA* parameter estimates are somewhat larger. Given that incidental truncation was found to characterize agricultural trade in the sample-selection model, these results are not surprising.[18] They point to parameter bias in log-linear models due to omitted observations.[19] This bias is not, however, severe.

Both models generated correct signs for the basic gravity variables, income and distance. The magnitude of the parameter estimates for these two determinants fall within conventionally acceptable levels. The statistically significant distance elasticities equal -0.78 in the benchmark models and -0.84 in the outcome equations of the sample-selection model. The generated income elasticities with respect to agricultural trade range from 0.71 for exporters to 0.79 for importers. The higher elasticity for imports is not unexpected given the relatively high demand for food in the developing countries.

The factor-endowment elasticity with respect to agricultural trade equals 0.18. The finding of a positive parameter estimate for the exporter-to-importer land/labor ratio shows that national resources are an important determinant of cross-border trade in agriculture. It provides empirical validation of the relevance of economic trade theory and the Heckscher-Ohlin (H-O) explanation of trade. H-O theory leads one to expect that the uni-directional flow of agricultural trade from *i* and *j* would be positively related to the relative land/labor ratio because the production of agricultural goods requires relative intensive use of arable land.

Coefficients for the invariant dyadic variables—landlockedness, common borders, language similarity, and colonial heritage—are statistically significant at the 0.01 level, and each has the hypothesized sign in tables 2 and 3. The cost to trade whenever either the exporter or the importer is landlocked imposes an ad valorem tax equivalent of 4 to 10 percent, given parameter estimates in the benchmark and Heckman models and the assumption that the elasticities of substitution range between 5 and 10.[20] Sharing a common border generates a competitive trade advantage for contiguous partners, providing them effectively with an ad valorem subsidy equivalent between

[17]The correlation between *MA* and *AA* is high. Classic signs of multicollinearity arose when both *MA* and *AA* variables were included in the same equation. The magnitude, sign, and statistical significance of these variables often changed upon removal of either one of them. To circumvent such statistical problems, we ran separate equations for (1) trade creation by including MA but not AA and (2) trade diversion by including *AA* but not *MA*.

[18]Rejection of the null hypothesis that $\rho = 0$ confirms the existence of correlation between the output and selection equations.

[19]Unfortunately, it was not possible to draw inferences about possible bias associated with missing observations and zero trade in our generalized gravity models. When attempting to apply the Heckman framework to these models, the Hessian became unstable, precluding convergence.

[20]According to Rose and van Wincoop and the theoretical underpinnings of the gravity framework identified by Anderson and van Wincoop, the coefficient of a time-invariant coefficient, such as landlockedness, is an estimate of $(\sigma - 1)\ln m$, where $(m - 1)$ is its tariff equivalent and σ is the elasticity of substitution.

Table 2
Benchmark gravity model (OLS)

Variables	Symbols	Coefficients		
		MA and AA	MA only	AA only
Exporter's income	$\ln(Y_i)$	0.71** (0.01)	0.71** (0.01)	0.71** (0.01)
Importer's income	$\ln(Y_j)$	0.79** (0.01)	0.79** (0.01)	0.79** (0.01)
Relative land/labor	$\ln(FE_{ij})$	0.18** (0.01)	0.18** (0.01)	0.18** (0.01)
Distance	$\ln(DT_{ij})$	-0.78** (0.02)	-0.78** (0.02)	-0.78** (0.02)
Common border	CB_{ij}	0.59** (0.08)	0.59** (0.08)	0.59** (0.08)
Landlockedness	LL_{ij}	-0.41** (0.04)	-0.40** (0.04)	-0.40** (0.04)
Language similarity	LS_{ij}	0.62** (0.04)	0.62** (0.04)	0.62** (0.04)
Colonial heritage	CH_{ij}	1.43** (0.09)	1.43** (0.09)	1.42** (0.09)
Mutual RTA membership	MA_{ij}	0.82** (0.24)	0.66** (0.05)	
Asymmetrical RTA membership	AA_{ij}	0.16 (0.24)		-0.61** (0.05)
Constant	C	15.49** (0.29)	15.64** (0.18)	16.30** (0.16)
Adjusted R^2		0.446	0.446	0.446
F-statistic		1,754	1,871	1,852
Root MSE		2.341	2.341	2.341
No. of observations		25,931	25,931	25,931

Notes: The dependent variable is the natural log of agricultural bilateral trade ($\ln X_{ijt}$) from country *i* to country *j* in year *t*. RTA = reciprocal trade agreement. MA = mutual-agreement index. AA = Asymmetric-agreement index. All regressions are estimated using 5-year panel data from 1975 to 2005. Coefficient estimates for the fixed time effects are not reported for brevity. Standard errors are in parentheses. They are calculated using White's heteroskedastic robust standard errors. ** denotes the null hypothesis is rejected at the 0.01 level.

Source: USDA, Economic Research Service.

Table 3
Heckman's sample selection model (MLE)

Variables	Symbols	Coefficients					
		MA and AA		MA only		AA only	
		Outcome	Selection	Outcome	Selection	Outcome	Selection
Exporter's income	$\ln(Y_i)$	0.71** (0.01)	0.42** (0.01)	0.71** (0.01)	0.42** (0.01)	0.71** (0.01)	0.42** (0.01)
Importer's income	$\ln(Y_j)$	0.79** (0.01)	0.31** (0.01)	0.79** (0.01)	0.31** (0.01)	0.79** (0.01)	0.31** (0.01)
Relative land/labor	$\ln(FE_{ij})$	0.18** (0.01)	0.00 (0.00)	0.18** (0.01)	0.00 (0.00)	0.18** (0.01)	0.00 (0.00)
Distance	$\ln(DT_{ij})$	-0.84** (0.02)	-0.38** (0.02)	-0.84** (0.02)	-0.39** (0.02)	-0.84** (0.02)	-0.38** (0.02)
Common border	CB_{ij}	0.77** (0.08)	-0.08 (0.12)	0.77** (0.08)	-0.08 (0.12)	0.78** (0.08)	-0.08 (0.12)
Landlockedness	LL_{ij}	-0.42** (0.04)	0.05* (0.02)	-0.42** (0.04)	0.05* (0.02)	-0.42** (0.04)	0.05* (0.02)
Language similarity	LS_{ij}		0.13** (0.02)		0.13** (0.02)		0.13** (0.02)
Colonial heritage	CH_{ij}	1.79** (0.09)	5.86** (0.06)	1.79** (0.09)	5.85** (0.06)	1.79** (0.09)	5.84** (0.06)
Mutual RTA membership	MA_{ij}	0.79** (0.24)	0.12 (0.32)	0.61** (0.05)	0.52** (0.10)		
Asymmetrical RTA membership	AA_{ij}	0.19 (0.24)	-0.42 (0.30)			-0.56** (0.05)	-0.52** (0.10)
Constant	C	16.08** (0.29)	2.51** (0.33)	16.25** (0.18)	2.10** (0.15)	16.87** (0.17)	2.61** (0.16)
No. of observations		32,572	32,572	32,572	32,572	32,572	32,572
Censored observations		6,641	6,641	6,641	6,641	6,641	6,641
Log likelihood		-70,770	-70,770	-70,772	-70,772	-70,777	-70,777
Wald-statistic		30,454	30,454	30,494	30,494	30,398	30,398
rho	ρ_μ	0.06	0.06	0.06	0.06	0.07	0.07
sigma	σ_ε	2.35	2.35	2.35	2.35	2.35	2.35
lambda	λ	0.15	0.15	0.15	0.15	0.16	0.16

Notes: The dependent variable is the natural log of agricultural bilateral trade ($\ln X_{ijt}$) from country *i* to country *j* in year *t*. RTA = reciprocal trade agreement. MA = mutual-agreement index. AA = Asymmetric-agreement index. All regressions are estimated using 5-year panel data from 1975 to 2005. Coefficient estimates for the fixed time effects are not reported for brevity. Standard errors are in parentheses. They are calculated using White's heteroskedastic robust standard errors. ** denotes the null hypothesis is rejected at the 0.01 level.

Source: USDA, Economic Research Service.

0.07 and 0.20 percent. However, contiguity was found not to affect the decision to trade in the selection equations.

The empirical results show that "cultural distances" matter. Language similarity and colonial heritage have the expected positive sign and are significant at the 1-percent level in the agricultural sector. The ability of a significant proportion of the population in both countries to communicate in the same language increases trade relative to other countries between 0.6 and 0.9 percent, on average. Possession of a colonial heritage also affects the decision to trade. Given an affirmative decision to trade, the colonial linkage augments bilateral trade in agriculture between 3 and 5 percent.

The benchmark and sample-selection models generated trade policy parameters that are similar in magnitude and statistical significance for each of the three specifications. The models that include both *MA* and *AA* variables provided statistical evidence that RTAs expand trade between member countries but no evidence that these agreements contract trade from nonmembers.

However, given the high correlation between the two trade-policy variables, multicollinearity causes difficulty in identifying the separate effects of *MA* and *AA*. We, therefore, ran separate equations, one excluding the mutual-agreement and the other excluding the asymmetric-agreement variables. Dropping one of the trade policy variables generated parameter estimates of the anticipated correct signs that were statistically significant at the 0.01 level. More specifically, the *MA* coefficients fell from 0.82 (0.79) in the *MA* and *AA* specification to 0.66 (0.61) in the *MA*-only benchmark (sample-selection) model. In addition, the *AA* coefficients became statistically significant in the two TD-only models, equaling -0.61 in the benchmark and -0.56 in the sample-selection models.

The long-run increase in RTA-induced trade between countries mutually belonging to the same agreements was found, on average, to outpace the fall in trade characterized by asymmetric membership. Results from the *MA*-only models show that, on average, mutual RTA membership enhances partner trade in agriculture between 93 and 84 percent for the benchmark and Heckman models, respectively.[21] Similarly, estimates from the *AA*-only models indicate that asymmetrical RTA membership lowers bilateral trade between 46 and 43 percent when the importer is a member of an RTA to which the exporter does not belong.

[21]The percentage change in trade attributable to landlockedness in the benchmark equation is $(e^{\beta 5} - 1)$ x 100.

Findings from the generalized models

The *MA* and *AA* coefficients were not statistically significant in the contemporaneous generalized gravity model when both trade-policy variables were included in the estimating equation (table 4, column 1). However, upon purging the equations of severe multicollinearity via the removal of either the *MA* or *AA* variable, the parameter estimates for both trade-policy variables became statistically significant at the 0.01 level and were of the correct sign (table 4, column 2 & 3). Interestingly, the 0.29 coefficient for *MA* and the -0.30 coefficient for AA are less than half the size of corresponding estimates in tables 2 and 3. The lower parameter estimates for the trade-policy variables indicate that the longrun percentage increase (decrease) in agricultural trade due to common (asymmetric) RTA membership is, on average, 34 (26)

Table 4
Generalized gravity model

Variables	Symbols	Coefficients MA and AA	MA only	AA only
Mutual RTA membership	MA_{ij}	0.09 (0.15)	0.29** (0.05)	
Asymmetrical RTA membership	AA_{ij}	-0.22 (0.16)		-0.30** (0.05)
Constant	C	14.11** (0.17)	12.85** (0.42)	13.48** (0.38)
Adjusted R^2		0.84	0.84	0.84
F-statistic		19.04	19.04	19.04
Root MSE		1.28	1.28	1.28
No. of observations		26,114	26,114	26,114

Notes: The dependent variable is the natural log bilateral trade ($\ln X_{ijt}$) from country *i* to country *j* in year *t*. RTA = reciprocal trade agreement. MA = mutual-agreement index. AA = Asymmetric-agreement index. All regressions are estimated using 5-year panel from 1975 to 2005 and include exporter-by-time, importer-by-time, and exporter-to-importer bilateral fixed effects omitted in the table for brevity. Robust standard errors are in parentheses. ** denotes the null hypothesis is rejected at the 0.01 level.

Source: USDA, Economic Research Service.

percent. The smaller RTA impacts generated by the generalized model are due to more comprehensive control of both observed and unobserved heterogeneity than in either the benchmark or Heckman models.[22]

Table 5 and 6 show the parameter estimates from our RTA phase-in gravity models for total agricultural trade. We calculate the sum of the contemporaneous and lag coefficients of *MA* and *AA* occurring over 10 years to gauge the cumulative impact of RTAs on partner trade as these agreements mature. The percentage change in trade expansion and trade contraction are reported as "total *MA* effect" and "total *AA* effect" when the sum of the parameter estimates $MA_t + MA_{t\text{-}5} + MA_{t\text{-}10}$ and $AA_t + AA_{t\text{-}5} + AA_{t\text{-}10}$ were determined to be significantly different from zero via Wald test statistics, respectively.

To examine whether RTAs may have had an impact on various partner combinations, we divided our global sample of observed trade flows into high-income (HIC), low-income (LIC), and all (ALL) exporter/importer groupings. We then ran the dummy-intensive gravity model on the following eight subsamples: ALL imports from ALL, HIC imports from ALL, ALL imports from HIC, HIC imports from HIC, LIC imports from HIC, LIC imports from ALL, ALL imports from LIC, LIC imports from LIC, and HIC imports from LIC.

The sum of the generated *MA* parameter estimates from our global sample of 19,225 agricultural trade flows equals 0.72 (table 5, column 1). This sum is similar to the 10-year cumulative MA estimates of 0.76 and 0.81, denoting trade expansion for total merchandise trade estimated by Baier and Bergstrand (2007) and for agricultural trade calculated by Grant and Lambert (2008), respectively.[23] Our estimate indicates that the longrun cumulative

[22]These empirical findings are consistent with results elsewhere. Magee (2008); Eicher and Henn (2009); and Baier and Bergstrand (2007) found that the inclusion of country-pair fixed effects in gravity equations lowered RTA parameter estimates.

[23]Neither of these studies addressed the issue of RTA-induced trade contraction.

Table 5
Agricultural trade expansion derived from generalized gravity equations with RTA phase-in effects

	1	2	3	4	5	6	7	8	9
	ALL imports from ALL	HIC imports from ALL	ALL imports from HIC	HIC imports from HIC	LIC imports from HIC	LIC imports from ALL	ALL imports from LIC	LIC imports from LIC	HIC imports from LIC
MA_{ijt}	0.18** (0.05)	0.07 (0.07)	0.03 (0.07)	0.17* (0.07)	-0.06 (0.14)	0.28** (0.10)	0.35** (0.10)	0.63** (0.17)	0.08 (0.15)
MA_{ijt-5}	0.24** (0.06)	0.23** (0.07)	0.21** (0.07)	0.32** (0.07)	0.03 (0.20)	0.19 (0.13)	0.07 (0.13)	0.02 (0.21)	-0.10 (0.21)
MA_{ijt-10}	0.29** (0.07)	0.14 (0.07)	0.10 (0.07)	0.05 (0.06)	-0.21 (0.22)	0.13 (0.15)	0.21 (0.17)	0.26 (0.22)	-0.04 (0.33)
Constant	13.85** (0.22)	15.49** (0.07)	16.12** (0.20)	17.86** (0.30)	14.44** (0.05)	13.18** (0.39)	12.99** (0.36)	12.86** (0.15)	14.46** (0.15)
MA_{ijt} sum	0.72** (0.08)	0.44** (0.09)	0.34** (0.09)	0.53** (0.09)	-0.24 (0.29)	0.61** (0.17)	0.63** (0.17)	0.90** (0.23)	-0.06 (0.40)
Total MA effect	1.05	0.55	0.40	0.70		0.84	0.88	1.46	
Adjusted R^2	0.86	0.90	0.90	0.94	0.85	0.81	0.82	0.76	0.86
F-statistic	14.51	16.59	19.35	31.69	11.04	9.44	7.67	5.95	7.36
Root MSE	1.18	0.94	0.91	0.54	1.05	1.32	1.35	1.53	1.10
No. of observations	19,225	8,076	8,263	2,994	5,269	11,149	10,962	5,880	5,082

Notes: The dependent variable is the natural log of agricultural bilateral trade ($\ln X_{ijt}$) from country *i* to country *j* in year *t*. RTA = reciprocal trade agreement. MA = mutual-agreement index. AA = asymmetric-agreement index. HIC = high-income countries. LIC = low-income countries. ALL = both high-income and low-income countries. All regressions are estimated using 5-year panel data from 1975 to 2005 and include exporter-by-time, importer-by-time, and exporter-to-importer bilateral fixed effects omitted in the table for brevity. The "total MA effect" measures the percentage change in bilateral trade attributable to mutual membership in an RTA. It is calculated when the MA_{ijt} sum is significantly different than zero. Standard errors are in parentheses. They are calculated using White's heteroskedastic robust standard errors. * and ** denote the null hypothesis is rejected at the 0.05 and 0.01 level, respectively.

Source: USDA, Economic Research Service.

impact of mutual membership in RTAs increases bilateral agricultural trade 105 percent, on average, beyond what would have occurred in the absence of these agreements when allowing for 10 years of phase-in effects.

Inspection of the empirical results from the various subsamples reveals that much of the agricultural trade expansion identified in the global sample stemmed from mutual RTA membership between countries in the low-income grouping. The payoff to agricultural LIC exporters belonging to the same RTA as their LIC partner was particularly pronounced, increasing 1.5-fold, on average (table 5, column 8). This finding suggests that RTAs may be a particularly effective policy instrument, serving as a catalyst to more open agricultural markets in the developing world.

Interestingly, there was no discernable increase in bilateral agricultural trade at mean values due to mutual RTA membership by either HIC exporters supplying affiliate LIC markets or by LIC exporters supplying affiliate HIC markets (columns 5 and 9). However, trade increased, on average, for HIC agricultural exporters supplying HIC markets when partners were members

Table 6
Agricultural trade contraction derived from generalized gravity equations with RTA phase-in effects

	1	2	3	4	5	6	7	8	9
	ALL imports from ALL	HIC imports from ALL	ALL imports from HIC	HIC imports from HIC	LIC imports from HIC	LIC imports from ALL	ALL imports from LIC	LIC imports from LIC	HIC imports from LIC
AA_{ijt}	-0.15** (0.05)	-0.04 (0.07)	0.02 (0.07)	-0.16* (0.08)	0.19 (0.15)	-0.23* (0.10)	-0.30** (0.10)	-0.59** (0.17)	0.03 (0.15)
AA_{ijt-5}	-0.26** (0.06)	-0.24** (0.08)	-0.27** (0.07)	-0.35** (0.07)	-0.14 (0.20)	-0.23 (0.13)	-0.06 (0.13)	-0.03 (0.21)	0.09 (0.21)
AA_{ijt-10}	-0.26** (0.07)	-0.14 (0.08)	-0.04 (0.07)	-0.03 (0.07)	0.45* (0.22)	-0.04 (0.15)	-0.23 (0.16)	-0.23 (0.21)	-0.05 (0.31)
Constant	14.79** (0.18)	16.46** (0.10)	15.51** (0.30)	18.26** (0.36)	13.90** (0.26)	13.59** (0.31)	13.78** (0.29)	13.60** (0.30)	14.52** (0.36)
AA_{ijt} sum	-0.67** (0.08)	-0.42** (0.09)	-0.28** (0.10)	-0.54** (0.09)	0.50 (0.27)	-0.50** (0.16)	-0.58** (0.17)	-0.85** (0.23)	0.07 (0.35)
Total AA effect	-0.49	-0.34	-0.24	-0.42		-0.39	-0.44	-0.57	
Adjusted R^2	0.86	0.90	0.90	0.94	0.85	0.81	0.82	0.76	0.86
F-statistic	14.46	16.54	19.35	32.02	11.10	9.43	7.66	5.95	7.34
Root MSE	1.18	0.94	0.91	0.54	1.05	1.32	1.35	1.53	1.10
No. of observations	19,225	8,076	8,263	2,994	5,269	11,149	10,962	5,880	5,082

Notes: The dependent variable is the natural log of agricultural bilateral trade ($\ln X_{ijt}$) from country *i* to country *j* in year *t*. RTA = reciprocal trade agreement. MA = mutual-agreement index. AA = asymmetric-agreement index. HIC = high-income countries. LIC = low-income countries. ALL = both high-income and low-income countries. All regressions are estimated using 5-year panel data from 1975 to 2005 and include exporter-by-time, importer-by-time, and exporter-to-importer bilateral fixed effects omitted in the table for brevity. The "total AA effect" measures the percentage change in bilateral trade attributable to mutual membership in an RTA. It is calculated when the AA_{ijt} sum is significantly different than zero. Standard errors are in parentheses. They are calculated using White's heteroskedastic robust standard errors. * and ** denote the null hypothesis is rejected at the 0.05 and 0.01 level, respectively.

Source: USDA, Economic Research Service.

of the same RTA (column 4). This trade increase is 70 percent in the long run.

The rise in RTA-member agricultural exports to RTA-member partners came at the expense of trade with other agricultural suppliers. In the global sample, agricultural sales fell 49 percent, on average, for exporters supplying import partners affiliated with RTAs to which the exporters did not belong (table 6, column 1). When comparing subsample results (columns 2-9), agricultural trade contraction was the least, falling 24 percent in the long run, for an HIC supplier exporting to a country in the set of ALL importers (column 3).[24]

[24]Similarly, agricultural trade creation was also the least for HICs exporting to the set of all importers, rising 40 percent.

Model Tradeoffs

RTAs are viewed by some analysts as a vehicle for government policymakers to use to circumvent domestic regulations in foreign countries by virtue of their ability to get "behind the border" and remove domestic barriers in foreign countries that inhibit partner trade. Lawrence (1996) posits, for instance, a link between the formation of RTAs and antitrust rules, product standards, corporate governance, tax codes, and internal shipping regulations. Yet such phenomena are not included in gravity equations because they are difficult, if not impossible, to quantify.

The absence of factors driving trade, such as domestic rules and regulations, in our benchmark and sample-selection models may yield biased and inconsistent coefficient estimates attributable to omitted variables. Errors-in-variable bias arises when variables omitted in applied models are correlated with both the dependent variable and one or more of the explanatory variables.

The first generalized model we estimate includes year, exporter-by-time, importer-by-time, and exporter-to-importer fixed effects. Year dummies control for numerous factors, including inflation common to all countries and the general increase in trade taking place due to globalization. The country-by-time fixed effects pick up domestic policies and country-specific macroeconomic shocks characterizing exporters and importers, as well as what Anderson and van Wincoop (2004) refer to as "multilateral resistances" that affect each trading partner. The exporter-to-importer fixed effects control for unobserved heterogeneity, such as unique institutional linkages and political arrangements characterizing each country pair.

The empirical results show that gravity models that do not comprehensively account for heterogeneity, via the inclusion of appropriate fixed effects, produce upwardly biased RTA coefficients. Note, for example, parameter estimates for the statistically significant RTA variables denoting MA and AA generated from the contemporaneous generalized gravity model are substantially smaller (less than one-half) than corresponding coefficients in either of the two conventional models.

The second generalized model we estimate is similar to the first. It includes the same set of fixed effects but also accounts for RTA lag effects. Empirical results indicate that the trade impacts of RTAs grow as producers and consumers adjust to policy-induced changes in the structure of markets and as the implementing provisions of these agreements are phased in over a period of 10 years.

The shortcoming of the two generalized models is that the intensive use of fixed effects sweeps away specific variables that trade theory identifies as driving cross-border trade. Neither of the generalized models, for example, can accommodate the relative resource endowment variable. Thus, no tests can be performed to determine if the exporter/importer-to-land/labor ratio is statistically significant. By contrast, both our benchmark and sample-selection models provide empirical evidence that relative factor endowment is an important driver of trade in agriculture, just as theory suggests.

Finally, we address concerns expressed in the literature about the possibility of bias in parameter estimates obtained from log-linear gravity models. The dependent variable in log-linear models is not really bilateral trade, but bilateral trade contingent on a trading relationship because the log of zero is not defined. Our empirical results show that dropping missing and/or unreported trade, as is commonly done, generates modestly biased estimates for some independent variables, including that of MA and AA. Interestingly, the coefficients generated by the OLS models were virtually identical and of the same level of statistical significance as those derived from the MLE models for the other explanatory variables (e.g., relative factor endowments).

Summary of Results

In this study, ERS examined the impact of reciprocal trade agreements on bilateral trade expansion and trade contraction in the world agricultural marketplace. We used a generic dummy variable to identify the influence on partner trade of mutual RTA membership. We innovated by developing and deploying a similarly constructed dummy variable, but one that is capable of detecting the influence of these agreements on trade between RTA member countries and their nonmember partners.

Four types of gravity equations were estimated: a benchmark model, a Heckman sample-selection model, a generalized model focused on contemporaneous impacts, and a generalized model that accommodates RTA phase-in effects. Model results provide empirical evidence that RTAs augment trade among and between countries mutually belonging to a common RTA, on average. We also find evidence that this increase in trade comes at the expense of other suppliers. Imports of agricultural goods by countries that belong to RTAs typically fall from exporters who do not share a common RTA membership with their trading partner. Interestingly, results in each of the four types of models show that the percentage increase in bilateral trade attributable to mutual RTA membership is greater than the percentage decrease in partner trade due to asymmetric membership.

Results from the benchmark models indicate that joint RTA membership, on average, boosts agricultural trade 93 percent in the long run, while the decrease in bilateral trade due to asymmetric membership is 46 percent. The Heckman sample-selection models depict somewhat lower longrun RTA impacts on bilateral trade. These models, which, unlike the OLS models, account for the absence of partner trade, show that membership in a common RTA generates 84 percent more agricultural trade between partner countries. Results also show that exports by countries supplying agricultural products to importers belonging to RTAs to which the exporter is not a member fall by 43 percent.

Our first generalized model focuses exclusively on the contemporaneous effect of RTAs. It generates much smaller RTA impacts than either the benchmark or Heckman models. This is due to the generalized model's comprehensive control of both observed and unobserved heterogeneity. Empirical results from this generalized model show that mutual RTA membership increases bilateral trade by 34 percent in the long run, on average. The model also shows that asymmetric membership decreases agricultural trade by 26 percent for countries importing from export suppliers not affiliated with an RTA to which the importer is a member.

Our second generalized model accounts not only for the contemporaneous impact of RTAs but also for their lagged effects. In our view, this model generates the most accurate estimates of RTA-induced trade expansion and trade contraction. It allows for implementation of the free-trade provisions of RTAs to be phased in over a period of years. It also allows for the time often required for market participants to adjust their behavior to RTA-induced changes in market structure.

The generalized model with phase-in effects estimates the 10-year cumulative increase in agricultural exports to RTA partners to be 105 percent in the long run (on average), or triple the contemporaneous impact. The cumulative decrease in trade for an exporter supplying agricultural goods to an import partner affiliated with an RTA to which the exporter does not belong is estimated to be 49 percent, almost double the contemporaneous impact of 26 percent. These findings demonstrate that the trade impacts of RTAs grow as producers and consumers adjust to policy-induced changes in the structure of markets.

Subsample estimations using the generalized gravity model with RTA phase-in effects revealed that much of the agricultural trade expansion identified in the global sample stemmed from mutual RTA membership between countries in the low-income grouping. The payoff was particularly pronounced when both partners were members of the same RTA, increasing 1.5-fold over the long run. This finding suggests that even though many policies in low-income countries continue to protect agriculture, RTAs are relatively effective instruments in removing impediments to bilateral trade. It also indicates that RTAs may open markets that were previously closed or nearly closed within the developing world. Even a small increase in agricultural trade induced by the formation of an RTA between two low-income countries generates a large percentage change in trade when the previous level of trade between them was low.

Interestingly, there was no discernable increase in agricultural trade due to mutual RTA membership by either high-income country exporters supplying affiliate low-income country markets or by low-income country exporters supplying affiliate high-income country markets, on average. Many developing countries, nevertheless, place a high priority on forging trade agreements with high-income countries rather than with low-income countries.

Policymakers may wish to think strategically when selecting partner countries with whom to form trade agreements. For example, a country is less likely to experience the adverse effects of import trade diversion when it chooses to form a trade alliance with countries whose exports are cost competitive with other foreign sources of supply. Similarly, a country is more likely to gain from export expansion by forging agreements with countries having high tariffs. The volume of cross-border trade is surely to grow with such countries as import levies are negotiated downward.

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Appendix: Economic Trade Theory and Advances in Applied Analyses

In the abstract world of neoclassical economics, relative price differentials provide incentives for cross-border trade that result in price convergence. However, given trade impediments such as transportation and other transaction costs in the real world, trade and domestic price differentials can persist if transaction costs equal differences in production costs. To further empirical understanding about the forces underpinning bilateral trade flows, Tinbergen (1962) and Pöyhonen (1963) pioneered estimation of gravity equations. The basic model can be expressed as follows:

$$V_{ij} = f(Y_i, Y_j, D_{ij}) \qquad (1)$$

where V_{ij}, the value of trade between countries *i* and *j*, is a positive function of Y_i and Y_j, the income (i.e., market size) of *i* and *j*, and a negative function of D_{ij}, the distance separating the two trading partners signifying transaction costs of commercial activity.

Many variations of the basic gravity model have been used in the literature to examine the factors hypothesized to drive product specialization and trade. Modified equations often include variables denoting specific supply conditions at the origin (e.g., factor endowments, technology), additional demand conditions at the destination (e.g., per capita income), and/or numerous economic forces that either assist or resist the movement of bilateral trade (e.g., colonial linkages, trade agreements).

Applied gravity analyses fell out of favor for a number of years due to data and statistical problems as well as to concerns about the absence of clear linkages to economic trade theory. Recent contributions in the theoretical and applied literature have, however, enhanced credibility and sparked a revival in gravity-based research.

A number of studies have strengthened microeconomic foundations. Deardorff (1998) addresses whether gravity models can work in the neoclassical world. He shows that the gravity equations are able to accommodate both the perfectly competitive Heckscher-Ohlin model and the monopolistic-competitive model of Dixit-Stiglitz (1977). Feenstra et al. (2001) develop a national (Armington) product and a monopolistic competition model, both of which include transaction costs. They conclude that a wider range of theories than previously recognized is consistent with the gravity-type equation. Evenett and Keller (2002) demonstrate that the gravity framework can be used to test for increasing-returns-to-scale and relative-factor-endowment explanations of trade under conditions of perfect and imperfect specialization. Eaton and Kortum (2002) derive a gravity model from the Ricardian theory of international trade. A recent contribution to this literature is the work of Anderson and van Wincoop (2003, 2004). They developed an analytical framework that establishes linkages between trade theory, in which prices play a central equilibrating role, and the generalized gravity model.

Anderson and van Wincoop (AvW) manipulate the constant-elasticity-of-substitution (CES) expenditure system to derive an operational model based upon trade costs. Market-clearing conditions are imposed to solve for general-equilibrium prices, prices that embody bilateral resistances confronting both the exporter and the importer with all of their trading partners. The most important insight obtained from their gravity model is that bilateral trade depends not only on the bilateral drivers, such as distance, characterizing the joint partnership of *i* and *j*, but also on multilateral drivers confronting exporter *i* and importer *j* in their other markets.

The generalized gravity equation that emerges from AvW's framework is consistent with economic theory:

$$\ln(X_{ij}) = \ln(Y_i) + \ln(Y_j) - \ln(Y_w) + (1-\sigma)\left[\ln(TI_{ij}) - \ln(P_i) - \ln(P_j)\right] \quad (2)$$

where X_{ij} is the value of exports from *i* to *j*; Y_i, Y_j, and Y_w are the outputs of country *i*, *j*, and the world (*w*), respectively; σ is the elasticity of substitution between the countries' goods; TI_{ij} represents trade impediments; P_i captures "outward multilateral resistances" that depict the average trade resistance between origin *i* and its importing partner; P_j embodies "inward multilateral resistances" that represent destination *j*'s average trade resistance with its supplying partners; and the θs denote income shares.

Fixed-effects statistical models can account for unobservable omitted variables (Feenstra, 2003). Given that the fixed-effects models are computationally easier to estimate than customized nonlinear least squares (NLS) models, most applied researchers have adopted the least squares dummy variables (LSDV) approach to estimating generalized gravity equations. The prototype model of the LSDV-type is as follows:[24]

$$\ln(X_{ij}) = \gamma_i + \gamma_j + \alpha_1 \ln(Y_i) + \alpha_2 \ln(Y_j) + \sum_{m=1}^{M} \beta_m \ln(TI_{ij}^m) + \varepsilon_{ij} \quad (3)$$

where the fixed effects (γ_i) and (γ_j) control for multilateral prices, each TI_{ij}^m represents a proxy vector denoting bilateral trade costs and ε_{ij} refers to the disturbance term.[25]

Recent developments in the applied literature have advanced gravity analyses by addressing statistical issues that had led to model misspecification and incorrect interpretation of empirical results in the early years. Mátyás (1997) and Egger and Pfaffermayr (2003) have shown that proper use of fixed effects can correct for omitted variables. Mátyás maintains that gravity models that test the significance of trading blocs are misspecified unless they are specified as a triple-index model that accounts for exporter, importer, and time fixed effects. Egger and Pfaffermayr assert that proper specification of the gravity equation includes, in addition to Mátyás's three indexes, bilateral fixed effects. Baier and Bergstrand (2007) present a case for using country-by-time and country-pair fixed effects in a theoretically motivated gravity equation. Baldwin (2006) recommends ignoring gravity results that do not comprehensively control for such heterogeneity.

[24]The term – $\ln(Y_w)$ is common across all countries and is therefore captured through a constant in the regression model. The term $\ln(Y_i) - \ln(P_i)$ is constant across all exporters for a given importer. It is captured by the exporter dummy, (δ_i). The term $\ln(Y_i) - \ln(P_i)$ is constant across all importers for a given exporter. It is captured through the importer dummy, (δ_j).

[25]The "trade costs" for exogenous factor *m* is $\rho_m = \beta_m / (1-\sigma)$, where is the substitution elasticity.