Impacts of Free Trade Agreements on Agricultural Trade Creation and Trade Diversion

Lin Sun and Michael R. Reed

This paper evaluates agricultural trade creation and diversion effects of the most important free trade agreements (FTAs). Trade creation and diversion effects are estimated using a Poisson Pseudo-Maximum-Likelihood (PPML) estimator with various fixed effects to deal with heteroskedasticity and zero trade observations. The analysis finds that PPML estimation is preferred to OLS and the estimated impacts of FTAs are different if zero trade observations are considered. The ASEAN-China preferential trade agreement, EU-15, EU-25, and Southern African Development Community agreements have generated large increases in agricultural trade among their members.

Key words: free trade agreements, agricultural trade, gravity model.

JEL codes: F13, F15.

There has been a rapid spread of economic regionalism across the world, especially in the last two decades. One of the most visible outputs from this expansion is the proliferation of free trade agreements (FTAs) among countries. The number of negotiated FTAs has reportedly risen to 380 in July 2007, which includes 205 arrangements that have already come into practice (World Trade Organization [WTO], Regional Trade Agreements database[1]). However, these agreements have had a controversial role in the Doha Development Round of the WTO. Some argue that multilateral trade negotiations have been hampered by the tremendous number of FTAs completed and under negotiation (Levy 1997). Others say that FTAs are a positive vehicle to move nations toward freer multilateral trade (Freund 2000; Ornelas 2005).

Economists have debated the merits of FTAs for a long time because of their well-known trade diversion possibilities (Viner 1950). Trade preferences for higher-cost producers with the FTA can shut out efficient third-party producers, resulting in trade diversion and well-known efficiency losses. The extent of these losses are unknown in many instances and are certainly dynamic as the number of FTAs increases and world markets change. On the other hand, the trade creation benefits of an FTA will depend on the initial economic structure (Burfisher, Robinson, and Thierfelder 2001). Furthermore, the character of each FTA varies, with some involving zero tariffs for members, while others talk about only a movement toward freer trade. Therefore, the extent of these trade creation and diversion effects is an empirical question.

This paper looks at the effects of FTAs on agricultural trade creation and trade diversion. According to our literature research, there are only three papers on this topic. Koo, Kennedy, and Skripnitchenko (2006) pay special attention to selected regional preferential trade agreements and examine their effect on agricultural trade volume through trade creation and trade diversion. Jayasinghe and Sarker (2008) investigate trade creation and diversion effects of the North American Free Trade

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[1] The website is http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx

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Agreement (NAFTA) on trade in six important agricultural products. They found that the agreement had increased intra-NAFTA trade greatly, but they could not pinpoint whether this was due to trade diversion. Lambert and McKoy (2009) analyze the effects of various FTAs on both intra- and extra-bloc agricultural and food product trade for three periods: 1995, 2000, and 2004. They find that membership in FTAs generally increases agricultural and food trade. For instance, agricultural trade among NAFTA members increased by 145% in 1995–2004. Their results support food trade diversion for members of the Caribbean Community and Common Market, the Central American Common Market, the Andean Community, and the Common Market for Eastern and Southern Africa (COMESA); yet they found that most FTAs create trade with nonmembers for food and agriculture.

This paper evaluates agricultural trade creation and trade diversion effects of the most important FTAs, but there are many novel aspects of this analysis. We estimate trade creation and trade diversion using a Poisson pseudo-maximum-likelihood (PPML) estimator with various fixed effects to deal with zero trade value problems. The analysis finds that the PPML estimation is preferred to ordinary least squares (OLS) and that the estimated impacts of FTAs are different if zero trade observations are considered. We also find that the FTA impacts are sensitive to the specification of the fixed effects and that those impacts vary over time.

This study contributes to the literature on the effects of FTAs on agricultural trade creation and trade diversion. First, no study of agricultural trade and FTAs has used the PPML method to deal with zero trade observations. Second, this study estimates the dynamic pattern of agricultural trade creation and trade diversion issues. We show that the effect of FTAs on agricultural trade creation and diversion vary over time. Finally, we use a three-way fixed effects gravity model to avoid endogeneity problems. These techniques provide improved estimates of FTA impacts on agricultural trade creation and trade diversion.

Literature Review: The Gravity Model, Endogeneity, and Zero Trade

The gravity model is the most successful trade analysis device of the last twenty-five years (Anderson 1979). Tinbergen (1962) was the first to perform an *ex post* analysis of FTAs using a gravity equation to analyze their effects on trade flows. Many authors have spent a great deal of effort to investigate theoretical models that would map into the gravity model specification—including Anderson (1979), Helpman and Krugman (1985), Bergstrand (1985, 1989), Deardorff (1998), Evenett and Keller (2002), and Anderson and Wincoop (2003). Frankel (1998) pointed out that the gravity equation passed from a poverty of theoretical foundation to an overwhelming richness (see also Cheng and Wall 2005). It has become the "workhorse" to analyze the *ex post* impacts of FTAs on trade flows (Eichengreen and Irwin 1998). In fact, the gravity model has also become a favored tool to assess the *ex post* trade creating and trade diverting effects associated with FTAs (Frankel 1997; Soloaga and Winters 2001; Carrere 2006).

Recently, researchers have struggled with two problems inherent in the gravity model. The first one involves potential endogeneity problems with FTAs, that there is potential reverse causality between higher trade volumes and FTAs in the gravity model. The higher level of trade between two countries might lead to a higher probability for the establishment of an FTA. In addition, there remain many unobserved ties between nations (except where the countries speak the same language and have a common colonial relationship) that both increase trade and make regional agreements more likely. Thus, the coefficient estimates are biased because the error term is correlated with the FTA dummy variables. Trefler (1993) and Lee and Swagel (1997) showed that previous estimates of trade liberalization impacts have been considerably underestimated. An alternative method of dealing with the endogeneity problem is to include fixed effects for bilateral country pairs and time-varying fixed effects for importer and exporter countries. Baier and Bergstrand (2007) and Magee (2003) have addressed the potential bias in gravity models caused by endogenous FTAs. The second problem involves zero observations when a double log model (the most common gravity specification) is used. Hallak (2006) and Helpman, Melitz, and Rubinstein (2008) addressed the existence of zero trade between country pairs in gravity models. Frankel (1997), Helpman, Melitz, and Rubinstein (2008), and Baldwin and Harrigan (2007) argue that the most obvious reason for zero-valued trade flows is the lack of trade among small and distant countries due to high trade costs. This issue is quite important because approximately 50% of the observations were zero in the data sets used by Santos Silva and Tenreyro (2006) and Helpman, Melitz, and Rubinstein (2008).

The existence of zero-valued trade flows becomes more obvious if the volume of trade in a specific good, rather than the volume of overall trade between two countries, is considered. Haveman and Hummels (2004) found that in virtually every country (99.4%), only 50% of the sectors imported goods. However, omitting zero value observations cause serious problems by deleting important information on low levels of trade (Eichengreen and Irwin 1998). This can lead to biased results, particularly when these zero-valued flows are nonrandomly distributed (Burger, Oort, and Linders 2009). Hurd (1979) points that heteroskedasticity can lead to large biases if samples are truncated by excluding zero values.

Past literature has dealt with this problem in one of three ways: (*a*) delete the observation with zero trade, (*b*) use some transformation, such as adding a small number to the zero observation, and (*c*) use a tobit model, and keep the zero observation. Santos Silva and Tenreyro (2006) show that dealing with the zero trade flows in these ways leads to inconsistent coefficient estimates if the constant-elasticity functional form is used. They also find that in the presence of heteroskedasticity the standard methods can severely bias the estimated coefficients, casting doubt on previous empirical findings. They propose a PPML method and find that it performs better than the other estimators in the presence of heteroskedasticity. Furthermore, Santos Silva and Tenreyro (2009) posit that the PPML estimator is generally well behaved even when the dependent variable has a large proportion of zeros. They argue that the PPML method provides a "natural way" to deal with zeros in trade data while providing consistent parameter estimates.[2]

The trade literature on agricultural trade suffers from the practice of deleting zero observations too. Grant and Lambert (2008) overcome the endogeneity bias with a time-varying importer and exporter fixed effects model, and measure the effects of FTAs for agricultural versus nonagricultural trade. They also focus on the length of the phase-in period for FTAs and find that they can last several years. However, they do not include agricultural trade creation and trade diversion impacts and do not include observations with no trade. Lambert and McKoy (2009) estimate trade diversion effects for food and agricultural products but use only cross-section data and do not correct for endogeneity bias. The analysis of Jayasinghe and Sarker (2008) suffers from all of the problems mentioned above.

Gravity Model Specification

Generally, the gravity equation can be written as:

$$(1) \qquad X_{ijt} = e^{(\sum \beta_i D_i)} GDP_{it}^{\beta_1} GDP_{jt}^{\beta_2} \times POP_{it}^{\beta_3} POP_{jt}^{\beta_4} sDIS_{ij}^{\beta_5} v_{ijt}$$

where X_{ijt} is the export volume from exporting country i to importing country j at time t; independent variables are defined in table 1 and the expected sign of each coefficient is identified. The D_i values are various dummy variables—identifying whether the country pair have a common language, colonial ties, shared borders, and membership in the same FTA. v_{ijt} is a nonnegative error term.

Taking the logarithm of equation (1) and including the dummy variables listed in table 1:

$$(2) \qquad LnX_{ijt} = \beta_0 + \beta_1 LnGDP_{it} + \beta_2 LnGDP_{jt} + \beta_3 LnPOP_{it} + \beta_4 LnPOP_{jt} + \beta_5 LnDIS_{ij} + \beta_6 Coml_{ij} + \beta_7 Coly_{ij} + \beta_8 Border_{ij} + \sum_m \gamma_m FTA_{ijt}^m + \sum_m \lambda_m FTA_{jt}^m + \sum_m \omega_m FTA_{it}^m + \varepsilon_{ijt}$$

where $\varepsilon_{ij} = Lnv_{ij}$ is the error term of equation (1). This log transformation is valid only for $X_{ijt} > 0$. The use of the logarithmic transformation to estimate the gravity

[2] The estimator is consistent under weak assumptions, and the trade data do not need to be distributed as Poisson; only the conditional mean needs to be correctly specified (Wooldridge 1999; Santos Silva and Tenreyro 2006). Furthermore, the data do not even have to be integers at all for the estimator based on the Poisson likelihood function to be consistent (Gourieroux, Monfort, and Trognon 1984). Westerlund and Wilhelmsson (2009) and Liu (2009) have already used this estimation procedure in their empirical analyses.

Table 1. Independent Variables and Expected Signs

Independent Variable	Description	Expected Sign
GDP_i	Gross domestic production of the exporting country *i* (million dollars)	+
GDP_j	Gross domestic production of the import country *j* (million dollars)	+
POP_i	Population of exporting country *i* (thousand)	−
POP_j	Population of importing country *j* (thousand)	−
DIS_{ij}	Distance between country *i* and *j*	−
$Coml_{ij}$	Dummy variable; = 1 if country *i* and *j* have a common official language	+
$Coly_{ij}$	Dummy variable; = 1 if country *i* and *j* have colonial ties	+
$Border_{ij}$	Dummy variable; = 1 if country *i* and *j* share a border	+
FTA_{ij}	Dummy variable; = 1 if country *i* and *j* both are members of the regional trade agreement	+
FTA_j	Dummy variable; = 1,if country *j* is a member of the regional trade agreement but country *i* isn't.	−
FTA_i	Dummy variable; = 1 if country *i* is a member of the regional trade agreement but country *j* isn't.	+

model creates an immediate difficulty when trade is zero, since the log of zero is undefined.

Given problems with the log-linear specification, there is increasing resistance to the log-linear model's use in bilateral trade analysis (Burger, Oort, and Linders 2009). More attention has been given to the use of Poisson models (Santos Silva and Tenreyro 2006; Burger, Oort, and Linders 2009; Westerlund and Wilhelmsson 2009).

We specify the empirical model as:

$$(3)\quad X_{ijt} = \exp\Big\{\beta_0 + \beta_1 LnGDP_{it} + \beta_2 LnGDP_{jt} + \beta_3 LnPOP_{it} + \beta_4 LnPOP_{jt} + \beta_5 LnDIS_{ij} + \beta_6 Coml_{ij} + \beta_7 Coly_{ij} + \beta_8 Border_{ij} + \sum_m \gamma_m FTA^m_{ijt} + \sum_m \lambda_m FTA^m_{jt} + \sum_m \omega_m FTA^m_{it} + \varepsilon_{ijt}\Big\}.$$

In equations (2) and (3), FTA^m_{ijt} is a dummy that takes the value 1 if both countries, *i* and *j*, belong to the same FTA *m*; zero, otherwise. FTA^m_{jt} is a dummy that takes the value 1 if importing country *j* is a member of FTA *m* and exporting country *i* belongs to the rest of the world; zero, otherwise. FTA^m_{it} is a dummy that takes the value 1 if exporting country *i* is a member of FTA *m* and importing country *j* belongs to the rest of the world; zero, otherwise.

The coefficient γ_m measures trade changes due to both countries being members of FTA^m. λ_m measures the extent to which members' imports are higher than normal levels from non-member countries, and ω_m measures the extent to which members' exports are higher than normal levels to nonmember countries.

Normally, $\gamma_m > 0$. If $\gamma_m > 0$ and $\lambda_m > 0(\omega_m > 0)$, there is pure trade creation[3] in terms of imports (exports). Generally, trade creation would be supported if within-bloc trade were enhanced ($\gamma_m > 0$) and trade with nonmembers increased ($\lambda_m + \omega_m > 0$). Trade diversion is suspected when $\gamma_m > 0$ and $\lambda_m + \omega_m < 0$ (Lambert and McKoy 2009). Specifically, $\gamma_m > 0$ along with $\lambda_m < 0(\omega_m < 0)$ indicates trade diversion in terms of imports (exports). At the same time, if $\gamma_m + \lambda_m > 0$ or $\gamma_m + \omega_m > 0$, we also call this trade creation. If the increase in intraregional trade is entirely offset by a decrease in regional imports from (exports to) the rest of the world, namely $\gamma_m + \lambda_m < 0(\gamma_m + \omega_m < 0)$, this is pure trade diversion in terms of imports (exports).

[3] Economists normally use trade creation when efficient producers increase production and exports. Trade diversion occurs when inefficient producers increase production and exports. In this context, it is impossible for us to identify efficient and inefficient producers. We use the term *trade creation* for additional trade due to both members being in the FTA; the term *import diversion* for lower trade when the importer is a member of the FTA and the exporter is not; and *export creation/diversion* for added/reduced trade when the exporter is a member of the FTA and the importer is not.

In order to control the individual effect of the time and country, we estimate three panel specifications:

- Equation (3) with time fixed effects, which adds $\alpha_t$to the equation
- Equation (3) with time, importer, and exporter fixed effects, which adds α_i, α_j, and α_t to the equation
- Equation (3) with time and bilateral country fixed effects, which adds α_t and α_{ij} to the equation

The time fixed effects (α_t) capture the time trend in trade and any shocks that affect global trade flows in a particular year. The bilateral country pair fixed effects (α_{ij}) control for the impact of omitted variables that are not included in our model, especially any unobserved characteristics of the country pair that are constant over time. The effects of other variables that are difficult to measure, such as infrastructure, factor endowments, multilateral trade liberalization, and unobserved country-specific shocks, are captured by the importer and exporter fixed effects (α_i and α_j).

The time and bilateral country pair fixed effect model is the classical three-way fixed effects model of Egger and Pfaffermayr (2003), and it is the most commonly used in gravity models (Micco, Stein, and Ordoñez 2003). Baldwin and Taglioni (2006) argue that this specification is superior to the other two, so we will spend more time explaining the results from this specification.[4] If restricted to one model, the third model specification is the one that we would choose. However, we fit all three for comparison purposes and a better linkage to past studies.

Most previous studies of regionalism make an implicit assumption that trade flows increase immediately to a new level with an FTA. They do not allow FTA impacts to vary over time. This assumption rules out the possibilities that the trade effects of the agreement may increase slowly over time (Magee 2008). The fact that FTAs often have a gradual reduction in tariffs over time rather than eliminating trade barriers immediately also makes it unrealistic to assume that the trade effects of FTAs are immediate (Frankel 1997; Magee 2008). Rose (2004), Baier and Bergstrand (2007), and Grant and Lambert (2008) have addressed this problem through phase-in effects.

In order to investigate whether FTA effects vary over time, we change the specified gravity equation to:

$$(4) \qquad X_{ijt} = \exp\Big\{\beta_0 + \beta_1 LnGDP_{it} + \beta_2 LnGDP_{jt} + \beta_3 LnPOP_{it} + \beta_4 LnPOP_{jt} + \beta_5 LnDIS_{ij} + \beta_6 Coml_{ij} + \beta_7 Coly_{ij} + \beta_8 Border_{ij} + \sum_m \sum_t \gamma_{tm}\left(D_t * FTA^m_{ijt}\right) + \sum_m \sum_t \lambda_{tm}\left(D_t * FTA^m_{jt}\right) + \sum_m \sum_t \omega_{tm}\left(D_t * FTA^m_{it}\right) + \varepsilon_{ijt}\Big\}$$

where D_t is a dummy variable identifying the year.

Data Description

The sample used for this analysis totals eighty-one countries: fifty-two developing countries, twenty-seven developed countries, and two transitional countries.[5] We use the stata command *xtpqml* for the estimation, with a sample period from 1993 to 2007, but we do not use every year in the analysis in order to reduce computational time; instead we use three-year intervals of agricultural bilateral data from 1993–2005 and include 2007, the last year of data. Therefore, there are 38,880 ((81 × 80) × 6) observations that include 7,482 bilateral

[4] A reviewer suggested that we fit the model with time-varying fixed effects. However, this model is not estimated because it would not allow the identification of some of the parameters of interest.

[5] The twenty-seven developed countries are: the United States, Japan, Singapore, Britain, Germany, France, Italy, Canada, Switzerland, Belgium, the Netherlands, Finland, Norway, Denmark, Sweden, Greece, Portugal, Spain, Austria, Australia, New Zealand, Ireland, Bahamas, Israel, South Korea, Hungary, and the Czech Republic. The fifty-two developing countries or regions are: Malaysia, Indonesia, Thailand, India, Mexico, Philippines, Brazil, Algeria, Egypt, Turkey, Argentina, Colombia, Chile, China, Hong Kong, Iran, Morocco, Saudi Arabia, United Arab Emirates, Barbados, Belize, Bolivia, Bulgaria, Burundi, Comoros, Dominica, Ecuador, Ethiopia, Grenada, Guyana, Jamaica, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Paraguay, Peru, Romania, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Seychelles, Sudan, Suriname, Trinidad and Tobago, Uganda, Uruguay, Venezuela, Zambia, and Zimbabwe. The sample includes two transitional economies: Russia and Poland.

country pairs. The number of zero trade observations is 12,343, which is nearly 32% of the sample.

The definition of agricultural product for this paper comes from the WTO agricultural statistics, which include Section 0, Section 1, Section 2 (not including Divisions 27 and 28), and Section 4. This is consistent with the Standard International Trade Classification; specifically, the data include food (food and live animals, beverages, tobacco, animal and vegetable oils, oil and wax, and fruit) and raw materials (leather, skins, rubber, timber, pulp and waste paper, fibers and their waste products, animal plant raw materials, etc.). Bilateral trade flow data come from the United Nations Commodity Trade Statistics Database (http://comtrade. un. org); we use nominal trade values. Data on gross domestic product (GDP) and population come from the World Bank Development Indicators database. Data on common language, border adjacency, colonial ties, and distance come from the Centre d'Etudes Prospectives et d'Informations Internationales (http://www.cepii.fr/anglaisgraph/bdd/distances.htm), which uses the great circle formula to calculate the geographic distance between countries, referenced by latitudes and longitudes of the largest urban agglomerations in terms of population. The WTO Regional Trade Agreements database is the main source for FTAs.

Empirical Results

The first set of results is the estimation of equation (3) with various fixed effects dummy variable schemes to control for endogeneity (columns 1, 2, and 3 in table 2). These are measuring the static effects of FTAs. For each specification, we also fit the typical gravity model specification (equation (2)) using OLS, which excludes zero trade observations. Table 2 includes the results listed in columns 1–3, which give results with fixed effects for time but not country, time and importer/exporter fixed effects, and time and bilateral country fixed effects, respectively.

The results vary widely between the OLS and PPML, so we perform a heteroskedasticity-robust Regression Equation Specification Error Test (RESET) for each estimated equation, which tests the correct specification of the conditional expectation (Ramsey 1969). The corresponding p-values are reported at the bottom of table 2. The RESET rejects the hypothesis that the test variable is zero for all of the OLS regressions, indicating that the OLS specification is inappropriate, but finds that the PPML regressions are appropriate. Santos Silva and Tenreyro (2006) had similar findings with their OLS and PPML equations. Thus, the PPML results are more trustworthy.

The model with only time fixed effects (see column 1) estimated using the PPML methods shows that all continuous variables have coefficients that are significantly different from zero except for the exporter's population. Exporter and importer GDP coefficients are close to unity, distance has a coefficient less than 1 in absolute value, and coefficients for a common border, common language, and colonial ties are all less than unity. There are significant pure trade creation effects for the Association of Southeast Asian Nations (ASEAN)–China Preferential Trade Arrangements (PTAs) and the Southern African Development Community (SADC). However, the intraregional trade effects for the 25-nation Euopean Union (EU-25) and NAFTA are negative.

The model controlling for time, importer, and exporter fixed effects (see column 2) was also used by Rose (2004). The PPML estimation for this model results in smaller coefficients for the GDP variables and a reversal in the significance and sign for the population coefficients compared with the PPML estimation listed in column 1. Other non-FTA dummy and distance coefficients are similar to the previous one. There are significant trade creation effects for ASEAN-China PTAs, COMESA, the fifteen-nation European Union (EU-15), and SADC, and the effects are larger for SADC and COMESA. Although the coefficients for the effect of intrabloc trade change from negative to positive for the EU-25 and NAFTA, they are not significantly different from zero. There is significant pure import diversion in NAFTA and among the EU-25, and pure export diversion is also found among the EU-25. Significant import diversion is also found for COMESA.

The empirical results listed in column 3 are estimated with time and bilateral country pair fixed effects. The distance and other time-invariant dummy variables fall out of the model because the bilateral country pair fixed effects encompass them. Both population coefficients turn negative and are significantly different from zero. There is pure trade creation for the ASEAN-China PTAs. Significant trade creation is found for the EU-15, EU-25, and SADC agreements, which are found to

Table 2. Static Effect of FTA on Agricultural Trade Creation and Trade Diversion

	1		2		3	
	Time but No Country Fixed Effect		Time and Importer and Exporter Country Fixed Effect		Time, Bilateral Country Pair Fixed Effect	
	OLS	PPML	OLS	PPML	OLS	PPML
Ln_GDP$_i$	0.68***	0.60***	0.28***	0.24***	0.18***	0.10*
	(52.57)	(31.05)	(5.00)	(2.76)	(3.36)	(1.87)
Ln_GDP$_j$	0.85***	0.88***	0.48***	0.52***	0.81***	0.67***
	(66.52)	(32.77)	(8.52)	(5.99)	(14.88)	(9.90)
Ln_POP$_i$	−0.00	−0.03	0.26***	0.19***	0.21**	−0.63*
	(−0.19)	(−1.53)	(2.91)	(3.54)	(2.17)	(−1.88)
Ln_POP$_j$	−0.16***	−0.14***	0.09	0.08	−0.07	−0.07***
	(−11.38)	(−7.38)	(1.00)	(1.29)	(−1.50)	(−2.71)
Ln_Distance$_{ij}$	−1.03***	−0.49***	−1.40***	−0.61***		
	(−61.70)	(−19.08)	(−69.81)	(−26.50)		
Border$_{ij}$	0.51***	0.67***	0.05	0.56***		
	(7.12)	(11.62)	(0.66)	(12.13)		
Comlang$_{ij}$	0.93***	0.27***	0.60***	0.39***		
	(26.02)	(5.81)	(15.30)	(9.49)		
Colony$_{ij}$	1.00***	0.26***	0.86***	0.28***		
	(15.48)	(4.43)	(13.06)	(4.18)		
ASEAN_ China	2.47***	0.98***	1.38***	0.40**	0.28*	0.35**
	(11.47)	(5.13)	(6.87)	(2.21)	(1.70)	(2.55)
ASEAN_ China_i	1.14***	0.40***	0.63***	0.18**	0.20***	0.08
	(15.33)	(4.75)	(8.39)	(2.33)	(3.37)	(1.28)
ASEAN_ China_j	0.28***	0.05	−0.29***	−0.12	0.13	0.12
	(2.70)	(0.37)	(−2.93)	(−0.99)	(1.64)	(1.30)
COMESA	−0.12	0.45**	−0.43*	0.92***	−0.44	0.32
	(−0.64)	(2.17)	(−1.75)	(2.90)	(−1.46)	(1.16)
COMESA_i	0.01	−0.33***	0.14	−0.03	−0.06	−0.02
	(0.21)	(−3.74)	(1.34)	(−0.21)	(−0.62)	(−0.23)
COMESA_j	−0.58***	−0.63***	−0.52***	−0.31*	−0.23*	−0.16
	(−8.15)	(−6.30)	(−4.91)	(−1.86)	(−1.93)	(−1.40)
EU_15	0.24***	0.16*	0.61***	0.85***	0.67***	0.54***
	(2.59)	(1.71)	(5.95)	(9.21)	(8.56)	(7.53)

continued

Table 2. continued

	1		2		3	
	Time but No Country Fixed Effect		Time and Importer and Exporter Country Fixed Effect		Time, Bilateral Country Pair Fixed Effect	
	OLS	PPML	OLS	PPML	OLS	PPML
EU_15_i	−0.03	−0.26***	0.16**	−0.08	0.01	−0.07*
	(−0.44)	(−3.56)	(2.43)	(−1.12)	(0.27)	(−1.67)
EU_15_j	−0.09	−0.27***	0.11	−0.13	−0.17***	−0.09**
	(−1.16)	(−3.07)	(1.57)	(−1.50)	(−3.54)	(−2.28)
EU_25	−0.02	−0.80***	0.25***	0.13	0.36***	0.45***
	(−0.34)	(−11.37)	(2.92)	(1.48)	(3.95)	(4.35)
EU_25_i	0.23***	−0.65***	0.12***	−0.43***	−0.12**	−0.09
	(4.83)	(−13.39)	(2.62)	(−8.81)	(−2.18)	(−1.46)
EU_25_j	0.14***	−0.79***	−0.03	−0.60***	−0.16***	−0.02
	(2.75)	(−10.67)	(−0.59)	(−8.15)	(−2.62)	(−0.43)
NAFTA	1.56***	−0.06	1.06***	0.09	0.26**	0.07
	(7.32)	(−0.51)	(2.99)	(0.40)	(2.47)	(1.06)
NAFTA_i	0.54***	0.22**	0.51***	0.21	0.14	−0.23***
	(8.41)	(2.01)	(4.84)	(1.22)	(1.51)	(−3.79)
NAFTA_j	−0.17**	−0.72***	−0.31***	−0.80***	0.03	−0.04
	(−2.36)	(−8.69)	(−2.93)	(−6.32)	(0.30)	(−0.58)
SADC	2.30***	1.77***	1.54***	1.58***	0.79**	0.98***
	(7.59)	(5.87)	(5.16)	(4.65)	(2.04)	(2.91)
SADC_i	0.53***	0.14	0.26**	−0.05	0.16	−0.10
	(4.75)	(1.09)	(2.19)	(−0.31)	(1.38)	(−1.15)
SADC_j	−0.07	0.13	−0.37***	−0.04	0.04	0.25**
	(−0.59)	(1.04)	(−2.96)	(−0.25)	(0.28)	(2.23)
_cons	−12.14***	−25.49***	−0.97	−14.96***	−12.64***	
	(−36.82)	(−32.89)	(−0.24)	(−3.26)	(−4.92)	
N	26003	38037	26003	38037	26003	31955
R^2	0.53	0.68	0.61	0.75	0.11	0.12
F-statistic	1237.87		489.33		84.17	
RESET	$F(1, 25970) = 27.11$	$\text{chi}^2(1) = 0.36$	$F(1, 25890) = 99.24$	$\text{chi}^2(1) = 0.45$	$F(1, 5427) = 11.88$	$\text{chi}^2(1) = 1.88$
	Prob > F = 0.0000	Prob > chi^2 = 0.5468	Prob > F = 0.0000	Prob > chi^2 = 0.5022	Prob > F = 0.0006	Prob > chi^2 = 0.1699

Note: *t*-statistics in parentheses; $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$; standard errors were calculated using White's heteroskedastic robust standard errors. The time dummy variables are not reported in order to save space. R^2 for PPML is the squared correlation between actual and fitted values of X_{ij}.

increase intratrade among members by 71.6%, 56.8%, and 166.4%, respectively. Significant export diversion is found for the EU-15 and for NAFTA—exports to outside nonmember countries are lower by 6.8% and 20.5%, respectively. Significant import diversion is found for only the EU-15, which reduced its imports from outside countries by 8.6%. Food regulations in the EU are likely a contributing factor to import diversion because third countries find it hard to meet EU regulations, while EU companies are forced to meet them. Significant pure import creation is found for only the SADC, which increased its imports from outside countries by 28.4%.

The findings on agricultural trade from NAFTA are not consistent with the work of others (Koo, Kennedy, and Skripnitchenko 2006; Jayasinghe and Sarker 2008). The results would attribute the increases in trade between the United States and Mexico and the United States and Canada to GDP growth and the nature of the bilateral relationships that these countries had over the observation period. NAFTA evidently did not enhance these relationships because they were already close.

As stated earlier, it is assumed that the impact of FTAs does not vary over time (table 2). Yet we know that most FTAs have a transition period, and firms take time to adjust to new economic conditions (Frankel 1997; Magee 2008). Thus, FTA effects are likely to have an important time dimension. Table 3 presents the model with time and bilateral country pair fixed effects that allow the FTA impacts to vary by year.[6] Thus, it is the dynamic counterpart of column 3 in table 2. The ASEAN-China PTAs and EU-25 are not included in the analysis because they have not been active long enough. Again, we perform a RESET for each estimated equation and find that the PPML is more appropriate than OLS estimation. We use an F-test to verify the existence of time-varying FTA effects. The hypothesis that there are no time-varying FTA effects is rejected at the 1% significance level with a value of 367.45.

The results in table 3 show clear trade creation dynamic effects from the EU-15 and SADC. There is export creation for COMESA and NAFTA in 1996, but this disappears and even becomes export diversion in later years. These same agreements show significant import diversion in early years, but it disappears in later years. The analysis shows that the import creation for SADC comes only in 2002 and 2007. Obviously, the FTA effects are quite dynamic.

There was no consistent export or import diversion for many of the agreements, but there were several years where some agreements diverted trade. For COMESA, there was significant export diversion in 2005 and 2007, and significant import diversion in 1996, 1999, and 2002. One must question the benefits for COMESA (at least for agriculture) when there is only one year of significant trade creation (2007) and much trade diversion. In contrast, the EU-15, which is a more encompassing agreement, has obvious trade creation effects for every year. The EU-15 has significant import diversion for only two of the early years, 1996 and 2002, and there is no significant export diversion.

The analysis shows no trade creation from NAFTA for any year, yet there is significant export diversion from 1999 to 2007 (after export creation in 1996). There is significant import diversion for NAFTA in 1996 and 1999. The SADC appears to be the model FTA in that there is significant trade creation in 2002 and 2005, and significant import creation in 2002 and 2007. It seems that SouthAfrica's strong promotion of the SADC's establishment led to better import access by third countries. This is not surprising given the numerous liberalizations that have occurred in South Africa since 1994.

Conclusions

This paper estimates the effects of free trade agreements using a PPML estimator, which avoids problems from using the logarithmic specification in the presence of heteroskedasticity and allows zero trade observations in the analysis (Santos Silva and Tenreyro 2006). The RESET test in this paper confirms that the PPML estimator is superior to the OLS in the gravity model analysis. The results are sensitive to the specification for fixed effects; nonetheless, some important conclusions are drawn from the analysis.

The ASEAN-China PTAs and the EU-15, EU-25, and SADC agreements have generated large increases in agricultural trade among their members. There was significant export and import diversion from the EU-15, but the creation of the SADC increased agricultural

[6] Only the coefficients for FTA variables are included in table 3 because they are the focus of our interest. The coefficients for non-FTA variables are available from the authors.

Table 3. Dynamic Effect of FTAs on Agricultural Trade Creation and Trade Diversion

	Time and Bilateral Country Pair Fixed Effect			Time and Bilateral Country Pair Fixed Effect	
	OLS	PPML		OLS	PPML
*COMSEA$_{ij}$*year_1996*	−0.17	0.33	*NAFTA$_{ij}$*year_1996*	0.22**	0.05
	(−0.49)	(0.79)		(2.11)	(0.85)
*COMSEA$_{ij}$*year_1999*	−0.71**	−0.12	*NAFTA$_{ij}$*year_1999*	0.12*	0.00
	(−2.17)	(−0.34)		(1.69)	(0.02)
*COMSEA$_{ij}$*year_2002*	−0.54	−0.33	*NAFTA$_{ij}$*year_2002*	0.21***	0.07
	(−1.30)	(−0.88)		(2.62)	(1.23)
*COMSEA$_{ij}$*year_2005*	−0.54	0.26	*NAFTA$_{ij}$*year_2005*	0.25**	0.03
	(−1.28)	(0.89)		(2.06)	(0.35)
*COMSEA$_{ij}$*year_2007*	−0.51	0.64**	*NAFTA$_{ij}$*year_2007*	0.48***	0.10
	(−1.15)	(2.08)		(2.70)	(1.12)
*COMSEA_i*year_1996*	0.13	0.23***	*NAFTA_i*year_1996*	0.36***	0.14**
	(1.24)	(3.23)		(3.29)	(2.29)
*COMSEA_i*year_1999*	0.22**	−0.02	*NAFTA_i*year_1999*	0.13	−0.20***
	(2.09)	(−0.17)		(1.23)	(−2.78)
*COMSEA_i*year_2002*	−0.27**	−0.12	*NAFTA_i*year_2002*	0.07	−0.27***
	(−2.15)	(−1.00)		(0.68)	(−4.07)
*COMSEA_i*year_2005*	−0.23*	−0.22**	*NAFTA_i*year_2005*	−0.02	−0.45***
	(−1.71)	(−1.96)		(−0.20)	(−5.68)
*COMSEA_i*year_2007*	−0.42***	−0.31**	*NAFTA_i*year_2007*	0.16	−0.41***
	(−2.97)	(−2.51)		(1.38)	(−4.76)
*COMSEA_j*year_1996*	−0.24*	−0.25**	*NAFTA_j*year_1996*	−0.01	−0.11***
	(−1.92)	(−2.05)		(−0.15)	(−2.68)
*COMSEA_j*year_1999*	−0.17	−0.23**	*NAFTA_j*year_1999*	−0.05	−0.16**
	(−1.34)	(−2.19)		(−0.46)	(−2.01)
*COMSEA_j*year_2002*	−0.29*	−0.42***	*NAFTA_j*year_2002*	0.05	−0.09
	(−1.96)	(−3.15)		(0.50)	(−1.22)
*COMSEA_j*year_2005*	−0.24	−0.01	*NAFTA_j*year_2005*	0.08	0.02
	(−1.55)	(−0.06)		(0.68)	(0.27)
*COMSEA_j*year_2007*	−0.24	−0.05	*NAFTA_j*year_2007*	0.02	0.03
	(−1.49)	(−0.27)		(0.20)	(0.32)
*EU15$_{ij}$*year_1996*	0.21***	0.30***	*SADC$_{ij}$*year_1996*		
	(2.73)	(5.42)			

$EU15_{ij}$ *year_1999	0.26***	0.39***	$SADC_{ij}$*year_1999		
	(2.75)	(3.99)			
$EU15_{ij}$ *year_2002	0.38***	0.47***	$SADC_{ij}$*year_2002	0.48	1.17**
	(3.56)	(4.30)		(1.00)	(2.43)
$EU15_{ij}$ *year_2005	0.49***	0.57***	$SADC_{ij}$*year_2005	1.14***	1.05***
	(4.32)	(4.64)		(2.74)	(2.68)
$EU15_{ij}$ *year_2007	0.49***	0.47***	$SADC_{ij}$*year_2007	1.16**	0.56
	(4.19)	(2.97)		(2.31)	(1.58)
EU15_i*year_1996	−0.02	0.04	SADC_i*year_1996		
	(−0.35)	(0.84)			
EU15_i*year_1999	−0.15**	−0.06	SADC_i*year_1999		
	(−2.27)	(−0.82)			
EU15_i*year_2002	−0.14*	−0.12	SADC_i*year_2002	0.52***	0.18
	(−1.94)	(−1.61)		(3.48)	(1.62)
EU15_i*year_2005	−0.22	−0.17	SADC_i*year_2005	−0.01	−0.05
	(−1.60)	(−1.43)		(−0.08)	(−0.51)
EU15_i*year_2007	−0.14	−0.15	SADC_i*year_2007	0.70***	0.11
	(−0.93)	(−0.90)		(3.92)	(0.88)
EU15_j*year_1996	−0.13**	−0.10***	SADC_j*year_1996		
	(−2.06)	(−3.16)			
EU15_j*year_1999	−0.21***	0.06	SADC_j*year_1999		
	(−3.13)	(0.61)			
EU15_j*year_2002	−0.26***	−0.15**	SADC_j*year_2002	0.07	0.28*
	(−3.50)	(−2.32)		(0.47)	(1.80)
EU15_j*year_2005	0.03	0.01	SADC_j*year_2005	0.19	0.10
	(0.27)	(0.04)		(1.14)	(0.67)
EU15_j*year_2007	0.16	0.14	SADC_j*year_2007	−0.12	0.31*
	(1.19)	(0.93)		(−0.65)	(1.90)
N	26003	31955			
R^2	0.12	0.16			
RESET	$F(1,5427) = 0.49$	$\text{Chi}^2(1) = 1.29$			
	Prob > $F = 0.4853$	Prob > $\text{chi}^2 = 0.2559$			

Note: t-statistics in parentheses; $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$; standard errors were calculated using White's heteroskedastic robust standard errors. We report only the main specific FTA coefficient in order to save space. R^2 for PPML is the squared correlation between actual and fitted values of X_{ij}.

exports to third-party countries. There is only export diversion for NAFTA; no trade creation is attributed to this agreement. The other variables, such as GDP and fixed effects, are obviously capturing the dynamic trade among NAFTA partners.

The *F*-test shows that FTA effects vary over time. There were many instances when the FTA had export creation effects early (for COMESA, EU-15, and NAFTA), but in most instances those effects disappear in later years. A new FTA might encourage firms to ramp up their exporting platform and reach out to third-party countries early, but then as the FTA transition continues, member countries become better markets and the export creation turns to export diversion.

The paper finds only limited evidence that FTAs have led to multilateral lowering of trade barriers for agricultural products. There is evidence that the SADC has imported more from third-party countries, but this is the only finding of export creation in this analysis. The dynamic results discover more import diversion among FTAs than the static results, so it is important that future analyses incorporate FTA effects by year. This import diversion is likely due to continued high agricultural tariffs for many non-FTA members. Thus, there is still much work to be done in the WTO to lower tariffs on agricultural products if the world is to reap the benefits from global free trade.

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