

It Is Much Bigger Than What We Thought: New Estimate of Trade Diversion

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November 23, 2012

Abstract

Conventional estimate of the trade diversion (TD) effect of preferential trade agreements (PTAs) tends to be much smaller than that of the trade creation (TC) effect. This paper examines two sources of estimation bias of the TD effect. The first bias of TD arises from the difficulty in controlling for multilateral resistance and other unobserved time-varying country heterogeneity when estimating both TC and TD effects simultaneously due to perfect multicollinearity. The second one is the underestimation of TD and arises from the failure to recognize that the concept of TD is inapplicable for a substantial proportion of PTAs and, thus, that the conventional method wrongly counts cases where trade cannot be diverted as cases where trade is not diverted. This paper corrects these two biases by using fixed effects and introducing a new measure of TD which provides a better mapping between the theoretical concept and data characteristics. Removing the two sources of bias leads to a twelve-fold increase in the estimate of the TD effect. It is found that the total TD effect is comparable to the TC effect in dollar terms.

JEL Code: F10, F15

Keywords: Gravity Equation; Trade Diversion; Multicollinearity; Unobserved Heterogeneity

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1 Introduction

One of the salient phenomena in international economy during the past two decades is a surge in preferential trade agreements (PTAs). As of January 2012, 511 of PTAs have been notified to the World Trade Organization (WTO), 319 of them were in force, and around 80% of them did not exist till the late 1990s. The recent literature has attempted to explain this dramatic explosion of PTAs in the light of trade diversion (TD), in which a member country switches its imports from a (more efficient) non-member to a (less efficient) member country. The domino theory by Baldwin (1993) suggests that when two countries form a PTA, the concern over its TD effect will give a third party country a stronger incentive to join the PTA. Likewise, Egger and Larch (2008) and Baier, Bergstrand, and Mariutto (2011) demonstrate that the efforts to eliminate TD by a third party country (competitive liberalization) or a member country (tariff complementarity) well explain the process of mushrooming PTAs. In essence, these studies suggest that as the TD effect of a PTA is sufficiently large, purportedly affected countries will try to establish their own PTAs (or joining the existing PTA) in defense; but as the ‘defensive’ PTAs themselves also trigger more PTAs, the number of PTAs grows exponentially.

In the empirical rim of the same field, a literature has been established to estimate the consequences of PTAs on bilateral trade flows. The most commonly adopted empirical framework to measure the PTA effect is the gravity equation, especially when one is interested in the general effect of all PTAs rather than the specific effect of individual PTA. Typically, in a gravity equation of the bilateral trade between importer i and exporter j over time t , the trade creation (TC) effect is supposedly captured by a PTA variable (PTA_{ijt}) constructed as a dummy variable that takes a value of one if i and j have a PTA at time t , and zero otherwise. Likewise, the TD effect is supposedly captured by an ‘other PTAs’ variable ($OPTA_{ijt}$) constructed as the number of PTAs that i has signed with other exporters k at time t , $\forall k \neq j$.¹ Examples of this approach include, for instance, Ghosh and Yamarik (2004); Carrere (2006); Magee (2008); Eicher, Henn, and Papageorgiou (2012).

Since a reduction of trade costs due to a PTA affects countries’ price indexes (multilateral resistance), which have non-linear effects on bilateral trade flows through general equilibrium channels as shown in Anderson and van Wincoop (2003), accounting for multilateral resistance or a country’s time-specific unobserved heterogeneity turns out to be important to avoiding omitted variable bias. The most widely used method to deal with this issue is to include country-time fixed effects (CTFEs), as in Rose and van Wincoop (2001); Feenstra (2004); Baier and Bergstrand (2007); Magee (2008); Helpman, Melitz, and Rubinstein (2008); Eicher, Henn, and Papageorgiou (2012). Simultaneously estimating the TC and TD effects while controlling for CTFEs, however, causes a perfect multicollinearity problem in the typical log-linear gravity equation. This is because PTA_{ijt} and $OPTA_{ijt}$ sum to the total number of PTAs signed by importer i at time t , which cannot be estimated in the presence of importer-time fixed effects. Thus, some of studies simply omit either the TD effect (e.g. Magee, 2008; Eicher, Henn, and Papageorgiou, 2012) or CTFEs (e.g. Carrere, 2006; Magee, 2008; Eicher, Henn, and Papageorgiou, 2012). Neither of these two solutions, however, are recommended as they may lead to incorrect inferences on the welfare implications of

¹The literature typically denotes $OPTA_{ijt}$ as TD_{ijt} . We avoid this notation in order to distinguish between the TD effect and the variable used to capture it.

PTAs if the TD effect is not negligible or if omitting CTFEs causes biased estimates for both the TC and TD effects.² Consequently, the failure to provide an unbiased estimate for the TD effect brings unclear message to policy makers whether reducing TD should be a main consideration in contemplating a new PTA as implied in Egger and Larch (2008) and Baier, Bergstrand, and Mariutto (2011).

The objective of this paper is to attempt to quantify the TD effect controlling for unobserved country-time heterogeneity in the gravity equation. We propose a new measure of OPTA variable that enables us to estimate the TD effect even with CTFEs so that we can avoid omitted variable bias. Overcoming the perfect multicollinearity problem aside, this new measure is preferable to the conventional measure also because it is based on a more accurate mapping of the theoretical concept of TD and data characteristics. Our findings show that controlling for time-varying country heterogeneity can remove significant upward bias in the estimates of both the TC and the TD effects and it results in a twelve-fold increase in the estimate of the TD effect. As a result, the TD and TC effects brought about by a PTA are comparable in dollar terms.

The rest of the paper is organized as follows: Section 2 discusses issues in measuring TD in the gravity equation. Section 3 introduces our approach to construct a new OPTA variable. Section 4 describes the data to be used and reports the estimation results. The last section concludes.

2 Measuring Trade Diversion in Gravity Equation

A typical gravity equation to examine the PTA effects on bilateral trade flows is:

$$\ln(T_{ijt}) = \alpha \mathbf{X}_{ijt} + \beta PTA_{ijt} + \gamma OPTA_{ijt} + u_{it} + v_{jt} + \omega_{ij} + \varepsilon_{ijt} \quad (2.1)$$

where T_{ijt} denotes imports by country i from j at time t ; PTA_{ijt} is the conventional variable used to capture the TC effect, as explained earlier; $OPTA_{ijt} = \sum_{k \neq j} PTA_{ikt}$ is the conventional variable used to capture the TD effect; $\mathbf{X}$ is a vector of control variables, such as income, distance, language, World Trade Organization (WTO) pair-membership, etc., depending on what FEs are present; u_{it} and v_{jt} are, respectively, unobserved time-varying importer and exporter heterogeneity; ω_{ij} is unobserved country-pair heterogeneity; and ε_{ijt} is an idiosyncratic error. $T_{ijt} + 1$, instead of T_{ijt} is used to allow for zero observations. To give zero and non-zero observations the flexibility to behave differently, we include an indicator for zero trade flows as an additional regressor.

The recent literature emphasizes the importance of controlling for unobserved country-pair heterogeneity, ω_{ij} such as cultural, historical or political ties as it may affect the likelihood of a PTA (see Glick and Rose, 2002; Egger and Pfaffermayr, 2004; Baldwin and Taglioni, 2006; Baier and Bergstrand, 2007). In addition, the literature also shows that the failure to control for the time-varying country heterogeneity, u_{it} and v_{jt} such as multilateral resistance and productivity shocks leads to omitted variable bias (see Anderson and van Wincoop, 2003; Baier and Bergstrand, 2007; Subramanian and Wei, 2007; Magee, 2008; Eicher, Henn, and Papageorgiou, 2012). To the extent

²Viner (1950) and following literature show that a PTA may deteriorate a member country's welfare due to TD. Krishna (2005) shows that TC should dominate TD to be welfare-improving for a member countries, and Treffler (2004) uses this approach to estimate the welfare effect of NAFTA for Canada, for example.

that such heterogeneity cannot be precisely measured or even observed, the literature further recommends to model them using CPFES (Baldwin and Taglioni, 2006; Baier and Bergstrand, 2007) and CTFES (Anderson and van Wincoop, 2003; Feenstra, 2004) in the gravity equation, in order to obtain unbiased estimates. The estimated TD effect without CTFES suffers from omitted variable bias as it includes the changes in extra-bloc trade not only from the discriminatory effect of PTA due to a change in relative prices, but also from the asymmetric effect from multilateral resistance or country-time specific shocks. For example, other things being equal, a PTA is expected to decrease the price index in the importing country, making it harder for non-member countries to capture the market share in the importing country. As shown in Anderson and van Wincoop (2003), this effect would be larger for smaller countries. This effect has to be accounted for in order to get unbiased estimates of the TC and TD effects.

Equation (2.1), however, confronts a perfect multicollinearity problem with the inclusion of u_{it} and v_{jt} . The problem arises from the fact that PTA_{ijt} and $OPTA_{ijt}$ sum to the total number of PTAs signed by importer i at time t , which is it -varying and thus perfectly correlated with u_{it} . As a result, we cannot identify both β and γ simultaneously while accounting for CTFES (strictly speaking, importer-time fixed effects only). Thus, previous studies either only focus on estimating TC effect (e.g. Magee, 2003; Cheng and Wall, 2005; Baier and Bergstrand, 2007), or estimate γ without accounting for unobserved country-time heterogeneity (e.g. Ghosh and Yamarik, 2004; Carrere, 2006; Magee, 2008; Eicher, Henn, and Papageorgiou, 2012), or use proxies such as remoteness measures to account for multilateral resistance (e.g. Baier and Bergstrand, 2004). However, the fitness of atheoretical remoteness measures is difficult to verify since multilateral resistance terms have non-linear effects of trade costs working through general equilibrium channels.³ For instance, Liu (2009) and Roy (2011) find that the estimated effects of WTO membership are substantially different depending upon whether remoteness measures or CTFES are used. The remoteness measure approach also ignores other multilateral trade costs such as border and language, and country-time specific aggregate shocks.

When the TD effect is estimated using CPFES, the literature sometimes finds γ to be very small compared to β ; for example, Magee (2008) finds that γ is equal to -0.003, implying a 0.3% ($=e^{-0.003} - 1$) decrease in extra-bloc trade as a result of a PTA, and that β is equal 0.35, implying a 42% of increase in intra-bloc trade. At first glance of these figures, one may conclude that as the TD effect is small in both absolute and relative terms, focusing only on the TC effect is innocuous. It is worth noting however that the estimated coefficient of TD represents changes in trade flows between a pair of countries only, the total TD effect on an importing country is equal to γ multiplying with the number of its trading partners, which can be large. As shown in Magee (2008), for instance, a 0.3% decline of extra bloc trade is equivalent of a fall of \$120 million of an importing country on average as imports from countries other than the members of a new PTA are around \$40 billion, and this is one-seventh of TC. It also implies that a small difference in the

³An alternative approach to account for multilateral resistance is to use a model-specific non-linear specification as in Anderson and van Wincoop (2003) or approximate the multilateral resistance terms using Taylor expansions as in Baier and Bergstrand (2009). However, the literature typically uses CTFES due to its easiness of implementation. Furthermore, the TD effect measured using the approximation approach would be restricted to changes in extra-bloc trade due to changes in multilateral resistance, thus strictly speaking it is not directly comparable to those obtained from the conventional method as the former encompasses other effects such as open bloc trade, which may arise when the member country changes trade policies against the non-member countries.

estimate for the γ coefficient may lead to a substantial change in the importing country's total TD estimate. For example, if γ is equal to -0.02 (2%) rather than -0.003 (0.3%), it will makes TD as large as TC. In short, the aggregate impact of TD is potentially large; as such, how to obtain an unbiased TD estimate is an important issue.

In what follows, we introduce an alternative measure of $OPTA_{ijt}$ to capture the TD effect. This new measure allows us to use CTFEs to account for unobserved time-varying country heterogeneity without confronting the perfect multicollinearity problem.

3 An Alternative Approach: The Weighted OPTA Measure

In the gravity model, the TD effect is conventionally measured by the coefficient on $OPTA_{ijt} = \sum_{k \neq j} PTA_{ikt}$, where PTA_{ikt} is a dummy taking a value of one if i and k are members of the same PTA at time t , and zero otherwise. That is, previous studies measure the TD effect as $\Delta T_{ijt} | (\Delta PTA_{ikt} = 1)$. This empirical strategy makes an implicit assumption that all PTA_{ikt} s are relevant to the identification of the TD effect. However, a closer examination of bilateral trade data reveals that the concept of TD is actually not applicable to a significant proportion of PTA_{ikt} s.

For a data set of N countries with T periods, there are $N(N-1)T$ $OPTA_{ijt}$ s (since $i \neq j$), and each $OPTA_{ijt}$ is composed of $(N-2)$ PTA_{ikt} s (i.e. $k = 1, 2, \dots, i-1, i+1, \dots, j-1, j+1, \dots, N$). Table 1 stratifies all of these PTA_{ikt} s into seven groups, based on the values of $T_{ij,t-1}$, T_{ijt} and T_{ikt} , where $k \neq j$.⁴ The concept of TD is applicable to some groups of PTA_{ikt} s, but not to some others.

First, the concept of TD is *definitely inapplicable* to group (a), where i does not import from k even after they have signed a PTA. This scenario, while seemingly counter-intuitive, can arise when there are plurilateral PTAs involving many members and some member-pairs have zero trade flows.⁵ As i and k do not trade, no trade between i and j can possibly be diverted from j to k .

Second, the concept of TD is *possibly inapplicable* to group (b), where i does not import from j before and after a PTA is formed between i and k . Whether the concept of TD is applicable here is ambiguous. On the one hand, since i and j have zero trade, no trade can be possibly diverted from j to k when a PTA is formed between i and k .⁶ On the other hand, it is possible that in the counterfactual of i and k not forming a PTA, i and j would have traded; if this is the case, then the observed zero trade between i and j at time t is indeed the result of the TD effect of the PTA between i and k .

Third, the concept of TD is also *possibly inapplicable* to groups (c) to (f), where there are missing values for either $T_{ij,t-1}$, T_{ijt} , or T_{ikt} . For groups (c) to (e), if the missing values for $T_{ij,t-1}$ or T_{ijt} are actually zero, then they resemble group (b); for group (f), if the missing values for T_{ikt} are actually zero, it resembles group (a).

⁴Since the stratification makes use of $T_{ij,t-1}$, we lose one period of observations. Therefore, there are, in total, $N(N-1)(N-2)(T-1)$ PTA_{ikt} s to be stratified.

⁵The case of $PTA_{ijt} = 1$ and $T_{ijt} = 0$ occurs in 11,675 country-pair observations out of the whole sample of 861,969. These are typically country-pairs that involve a very small country (such as Barbados, Belize, Dominica, French Polynesia, Grenada, Lesotho, New Caledonia, and Saint Lucia) and their current or former European colonizers.

⁶However, it is possible that the PTA between i and k will cause the trade flows between i and j to increase from zero to a positive value if the income effect of the PTA on i is sufficiently large (Kowalczyk, 2000). This scenario is included in group (g).

Last, the concept of TD is *definitely applicable* to group (g), which consists of all remaining combinations of the values of $T_{ij,t-1}$, T_{ijt} and T_{ikt} .

Given the concept of TD is definitely inapplicable to cases in group (a), we filter them out in the construction of a new OPTA variable, $OPTA_{ijt}^\theta$, by weighting PTA_{ikt} with θ_{ikt} as in (3.1):

$$\begin{aligned} OPTA_{ijt}^\theta &= \sum_{k \neq j} PTA_{ikt} \cdot \theta_{ikt} \\ \theta_{ikt} &= \begin{cases} 0 & \text{if } PTA_{ikt} \in \text{group (a)} \\ 1 & \text{otherwise} \end{cases} \end{aligned} \quad (3.1)$$

The distinction of $OPTA^\theta$ from the conventional $OPTA$ variable comes from the extent by which the PTA_{ikt} variable is ‘discounted’: the more frequently an ij -pair has $T_{ikt} = 0 \forall k \neq j$, the more PTA_{ikt} variables are discounted. Therefore, $OPTA_{ijt}^\theta \leq OPTA_{ijt}$ always holds and the equality holds only if $T_{ikt} > 0 \forall PTA_{ijk} = 1$.⁷ This also implies that as long as the inequality holds, the conventional measure $OPTA_{ijt}$ understates the estimate of the TD effect (i.e., the coefficient of the latter is less negative than the former) because it wrongly counts cases where trade *cannot be diverted* as cases where trade *is not diverted*.

Substituting $OPTA_{ijt}^\theta$ for $OPTA_{ijt}$ in the gravity equation will also solve the multicollinearity problem because the sum of it with PTA_{ijt} is now ijt -varying. The TD effect is now measured as $\Delta T_{ijt} | (\Delta PTA_{ikt} = 1 \text{ and } T_{ikt} > 0)$; that is, a condition of $T_{ikt} > 0$ is imposed to reinforce the theoretical concept of TD.

If the argument behind the weighted $OPTA$ measure approach is valid, then one should find no TD effect from the PTA_{ikt} s belonging to group (a). This corollary can be tested empirically. First, it should be noted that $OPTA_{ijt} \equiv OPTA_{ijt}^a + OPTA_{ijt}^\theta$, where $OPTA_{ijt}^a = \sum_{k \neq j} PTA_{ikt} (1 - \theta_{ikt})$ is the total number of PTAs signed by i and k at time t that belong to group (a) and $OPTA_{ijt}^\theta$ is that which belongs to groups (b) to (g).

Using this we can modify (2.1) into (3.2):

$$\begin{aligned} \ln(T_{ijt}) &= \alpha \mathbf{X}_{ijt} + \beta_1 PTA_{ijt} + \gamma_a OPTA_{ijt}^a + \gamma_\theta OPTA_{ijt}^\theta \\ &\quad + u_{it} + v_{jt} + \omega_{ij} + \varepsilon_{ijt} \end{aligned} \quad (3.2)$$

and test the hypothesis of $\gamma_a = 0$.

Once we have verified that $\gamma_a = 0$, we can drop $OPTA_{ijt}^a$. This will immediately solve the multicollinearity problem, allowing us to estimate the resulting gravity equation using annual CTFEs.

As a robustness test, we also consider weighting PTA_{ikt} by π_{ikt} to sort out the cases in group (g) of Table 1, as in (3.3):

⁷The weight can be further embellished to reflect the size of T_{ikt} instead of just being 0 or 1, but we do not pursue differentiated weight in this paper.

Table 1: Categorization of cases

Scenario	(a)	(b)	(c)	(d)	(e)	(f)	(g)
$T_{ij,t-1}$	any	0	0	.	.	any	remaining combinations
T_{ijt}	any	0	.	0	.	any	
T_{ikt}	0	+	+	+	+	.	
Applicability of TD	no	ambiguous					yes
Share of cases*	43.2%	27.9%					28.9%
Share of cases**	33.0%	12.7%					54.3%

Note: "." represents missing. * represents the share of each scenario for all cases and ** represents the share of each scenario for cases conditional on $\Delta PTA_{ikt} = 1$, respectively. The counting unit here is case, not observation. For each observation ijt , there are ikt cases which include all other countries $k \neq j$. Since our sample includes 216 countries over 31 years, therefore if there were no missing data, the total number of observations would have been $216 \times 215 \times 30$ and the total number of cases $216 \times 215 \times 30 \times 215$ (one period is lost due to the use of a lag value).

$$\begin{aligned}
 OPTA_{ijt}^{\pi} &= \sum_{k \neq j} PTA_{ikt} \cdot \pi_{ikt} \\
 \pi_{ikt} &= \begin{cases} 1 & \text{if } PTA_{ikt} \in \text{group (g)} \\ 0 & \text{otherwise} \end{cases}
 \end{aligned} \tag{3.3}$$

The difference between the two weighting functions is that, in using θ (π) we emphasize on *excluding* (*including*) the cases for which the concept of TD is *definitely inapplicable* (*definitely applicable*). Between the two, θ is preferred for the following reason. As observed in Table 1, the weighting scheme that defines $OPTA^a$ and thus $OPTA^{\theta}$ is based on the value of T_{ikt} only and thus is independent of the dependent variable T_{ijt} ; as such it does not cause any endogeneity concerns. On the contrary, the weighting scheme that defines $OPTA^{\pi}$ and $OPTA^g$ is based on the values of T_{ijt} as well as T_{ikt} , and therefore could potentially create an endogeneity problem. However, whether the problem will materialize in the empirical analysis is not clear because only in groups (b) and (d) does the specific zero value of T_{ijt} matter. In fact, as shown later, the results of using θ and π turn out to be very similar.

By filtering out those PTA_{ikt} s to which the concept of TD is inapplicable, this approach can correct the bias associated with the conventional construction of $OPTA_{ijt}$. It is worthwhile to stress that this correction could be important in its own right, regardless of the multicollinearity issue. As shown in Table 1, in our data set more than 40% of PTA_{ikt} s belong to group (a), and adding those from groups (b-f) sees the share of inapplicable cases increase to over 70%. Even if we focus on those PTA_{ikt} s that have changed their value from time $t - 1$ (i.e. $\Delta PTA_{ikt} = 1$), the share of inapplicable cases is still more than 30% when only group (a) is considered, and increases to over 45% when groups (b-f) are also included. This implies that using the proposed method makes significant differences to the value of the $OPTA$ variable as compared to the conventional method.

Table 2: Testing the coefficients on stratified OPTA variables

	(1)	(2)	(3)	(4)
<i>PTA</i>	.4436* (.0271)	.4456* (.0271)	.4490* (.0271)	.4480* (.0271)
<i>OPTA^a</i>	-.0011 (.0019)			
<i>OPTA^θ</i>	-.0124* (.0020)	-.0113* (.0008)		
<i>OPTA^{a-f}</i>			.0003 (.0020)	
<i>OPTA^π</i>			-.0115* (.0020)	-.0118* (.0009)
CPFEs	yes	yes	yes	yes
CTFEs	2-yr	2-yr	2-yr	2-yr
Model	Log-linear			
No. of obs.	861,969			

Notes: Cluster (country-pairs) robust standard errors are reported in parentheses. * indicates that the coefficient is statistically significant at 10% level.

4 Empirical Results

Our data are obtained from Christopher Magee's website.⁸ The data cover 216 countries from 1980 to 2010. The PTA and GATT/WTO membership data are from the WTO, and our measure of PTA includes customs unions and free trade agreements.

4.1 Testing the coefficients on stratified OPTA

First, we estimate equation (3.2) to verify that $\gamma_a = 0$ so that we can drop $OPTA_{ijt}^a$. However, (3.2) confronts the same multicollinearity problem as (2.1) does. Thus, we use another method to circumvent this issue, which is also used for other robustness checks later. In this method, we allow CTFEs to vary every *two* years, rather than every year; i.e., $u_{it} = u_{i,t+1}$ and $v_{jt} = v_{j,t+1}$ for $t = 1, 3, 5 \dots$ in (3.2). Since CTFEs vary only biennially, we also include time fixed effects (TFEs), μ_t , in the estimation. We argue that this specification is acceptable as our dataset is annual and both multilateral resistance (which is a relative price) and country-specific aggregate shocks are unlikely to fluctuate much on an annual basis. This method allows us to identify β_1 , γ_a and γ_b simultaneously as long as there are sufficient changes of PTA_{ijt} and $OPTA_{ijt}$ within the two-year window.

Table 2 shows that estimation results from testing the hypothesis of $\gamma_a = 0$ with CPFEs and biennial CTFEs. In column (1), we cannot reject the hypothesis of $\gamma_a = 0$ at standard significance levels. Dropping $OPTA^a$ from the regression, as in column (2), produces statistically indifferent estimates for the PTA and $OPTA^\theta$ coefficients and the differences of point estimates are negligible,

⁸The data are available at <http://www.facstaff.bucknell.edu/cmagee/>.

Table 3: Trade creation and trade diversion

	(1)	(2)	(3)	(4)	(5)	(6)
<i>PTA</i>	.5513*	.4123*	.4459*	.4456*	.4474*	.5993*
	(.0269)	(.0266)	(.0272)	(.0271)	(.0275)	(.0324)
<i>OPTA</i>	-.0042*	-.0010				
	(.0005)	(.0013)				
<i>OPTA</i> ^θ			-.0122*	-.0113*		-.0143*
			(.0009)	(.0008)		(.0019)
<i>OPTA</i> ^π					-.0124*	
					(.0009)	
CPFEs	yes	yes	yes	yes	yes	yes
CTFEs	no	2-yr	1-yr	2-yr	1-yr	2-yr
Control	A	B	B	B	B	B
Model			Log-linear			Heckman
No. of obs.			861,969			411,196

Notes: Cluster (country-pairs) robust standard errors are reported in parentheses. Control variables A include import-country log real GDP, export-country log real GDP, and WTO membership, and control variables B include WTO membership.* indicates that the coefficient is statistically significant at 10% level.

implying that there is no risk of omitted variable bias with its removal. In column (3), we use the alternative stratification of $OPTA \equiv OPTA^{a-f} + OPTA^{\pi}$, where $OPTA_{ijt}^{a-f} = \sum_{k \neq j} PTA_{ikt} (1 - \pi_{ikt})$ is the total number of PTAs signed by i and k at time t that belong to groups $(a - f)$ and $OPTA_{ijt}^{\pi}$ is that which belongs to group (g) . Once again, we cannot reject the hypothesis of $\gamma_{a-f} = 0$ at standard significance levels. Dropping $OPTA_{ijt}^{a-f}$ from the regression, as in column (4), also has little effect on the estimates of PTA and $OPTA^{\pi}$ coefficients.

To conclude, the empirical evidence confirms that groups (a) and $(b - f)$ contribute little to the estimation of TD effect. Therefore, in applying the weighted measure approach in the next section, we substitute $OPTA_{ijt}^{\theta}$ (or $OPTA_{ijt}^{\pi}$) for $OPTA_{ijt}$ and use its coefficient as a measure of the TD effect.

4.2 Estimation of the Trade Diversion Effect

Table 3 reports the estimation results using the conventional as well as the new approach. Columns (1) and (2) use the conventional variable $OPTA$. Column (1) does not include CTFEs to avoid perfect multicollinearity, while column (2) includes biennial CTFEs to achieve the same purpose. First, a comparison of the two columns indicates that controlling for CTFEs substantially reduces biases of the TC and TD estimates. This result emphasizes the importance of the inclusion of CTFEs. Column (3) uses the weighted $OPTA$ measure, $OPTA^{\theta}$ controlling for both CPFEs and CTFEs. The weighted measure approach leads to a more than twelve-fold increase in the estimate of the TD effect compared to that in column (2) while the TC estimates are not statistically different from that in column (2). This finding reveals that the weighted measure approach corrects significant upward bias of the TD estimate. One may concern that the difference of the TD estimates in

columns (3) from that in column (2) may be attributed to different CTFEs (one is annual and the other is biennial) and not to the new measure of *OPTA*. To see if that is the case, in column (4) we repeat the regressions as in columns (3) but using biennial CTFEs. The results show that the point estimates of the coefficients for both *PTA* and *OPTA* are very similar, and they are statistically indifferent from those in column (3). This means that the unbiased estimate of TD in column (3) is largely due to the use of the weighted *OPTA* variable.

To see the policy implication of the findings, we compare the TC and TD estimates in dollar terms using the conventional and new approaches, respectively. On average, a member country imports \$420 million from other member countries and \$21 billion from non-member countries when it forms a new PTA. It indicates that in column (1), 74% increase in intra-bloc trade is equivalent to a rise of \$311 million of imports from members and a decrease of 0.4% of extra-bloc trade is equivalent to a fall of \$88 million of imports from non-members, meaning that TD is around one-third of TC. When we use biennial CTFEs in column (2), the TD effect is statistically insignificant, and decreases to one-tenth of the TC effect. When we use the weighted *OPTA* measure and take into account of CTFEs in column (3), TD is as large as TC in that extra bloc trade decreases by \$252 million while intra-bloc trade increases by \$235 million. In summary, controlling for CTFEs reduces biases substantially and the weighted *OPTA* measure approach provides an TD estimate that is statistically and economically much more significant than that from the conventional *OPTA* measure.

4.3 Sensitivity Tests

Two more regressions are implemented to examine whether the aforementioned results are sensitive to i) the measure we proposed and ii) the way to treat the zero observations of the dependent variable. First, we use $OPTA^\pi$ instead of $OPTA^\theta$ in the estimation, and the results are shown in column (5) of Table 3. The estimated coefficient for the TD effect is very similar to that in column (3). This indicates that the results are robust to the inclusion of the ambiguous cases of groups ($b - f$) in the weighted measure of *OPTA*. Next, to check whether a different approach to the zero observations will change our results, in column (6) we use Heckman's (1979) two-step procedure to allow for sample selection into bilateral trade.⁹ To take into account the unobserved time-varying country heterogeneity, we can only allow biennial CTFEs. This is because in the Heckman's procedure only observations with positive value of dependent variable are used in the estimation and, as a result, $OPTA^\theta$, *PTA* and annual CTFEs are perfectly correlated.¹⁰ Following Helpman, Melitz, and Rubinstein (2008) we use religious proximity and other fixed costs of trade as exclusion restrictions.¹¹ Column (6) reports the results. The coefficient of $OPTA^\theta$ still remains

⁹In the recent literature Silva and Tenreiro (2006) proposes using the Poisson Pseudo Maximum Likelihood (PPML) method to deal with the zero observations. Conditional PPML method can be used if one wants to control for CPFEs only. However, we do not consider this method because it does not properly account for country-time heterogeneity, which is part of the motivation of this paper.

¹⁰Using $OPTA^\pi$ instead of $OPTA^\theta$ still confronts the same problem because the two are highly correlated.

¹¹See Helpman, Melitz, and Rubinstein (2008) for the source and measure of religious proximity. We use the following four other variables to measure the fixed costs of trade as in Magee and Massoud (2011): (i) kilometer (*km*) of waterways per km^2 of land area, (ii) *km* of railways per km^2 of land area, (iii) *km* of highways per km^2 of land area, and (iv) airports per km^2 . The data are available at <http://www.facstaff.bucknell.edu/cmagee/>. For each variable, we average the values of importer-country and exporter-country. As the religion data are available for only two time

as large as the one in column (3), indicating that our findings are not sensitive to the methods we apply to deal with zero observations.

5 Conclusion

Trade diversion (TD) has been considered as an important element in inferring the welfare implication of PTAs. The most common instrument to measure the TD effect of general PTAs *ex post* is the gravity equation. However, due to the perfect multicollinearity problem when simultaneously estimating the trade creation (TC) and TD effects in the presence of country-time fixed effects (CTFEs) in the linear gravity equation, the conventional method to measure the TD effect fails to take into account unobserved country-specific time-varying heterogeneity and, thus, gives rise to biased estimation. Moreover, conventional TD measure underestimates TD effect by including inapplicable cases in counting other PTAs. Thereby, previous findings tend to suggest a much smaller TD effect compared to the TC effect. In this paper, we introduce the weighted OPTA measure adherent to the concept of TD to overcome this problem. The new approach allows us to simultaneously estimate the TC and TD effects in the presence of CTFEs. Our results show: (i) that not accounting for unobserved time-varying country heterogeneity in the gravity equation leads to significant bias in the estimates of the TD effect; (ii) that the conventional construction of the *OPTA* variable leads to significant underestimation of the TD effect; and (iii) that based on the unbiased estimate the size of the TD effect in aggregate is comparable to that of the TC effect in dollar terms.

Our finding has important policy implications. The recent theoretical literature suggests that the mushrooming of PTAs could be explained by the fact that countries try to use their own PTAs as a defense device to fence off any negative TD effects arising from the PTAs formed by their trading partners with a third party country. Our findings lend much stronger empirical support to this theoretical argument than the previous empirical literature. This also implies that, from the policymaker's perspective, the merit of PTAs lies not only on the new trade opportunities they create, but also on the existing trade opportunities they protect.

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points (1970 and 2000), we extrapolate them for other unavailable years. We use the 1970 data for years before 1985, the mean of 1970 and 2000 for years between 1986 and 1995, and 2000 data for 1996 onward. Fixed costs in relation to infrastructure are also available for the limited time period. For example, one of the variables, waterways per km^2 of land area are available for the time period between 1992 and 2004. We use the 1992 data for years before 1992 and 2004 data for 2004 onward. As for the regressions, we use the mixture of various fixed costs and religious proximity. The results we obtain from different combinations of variables are qualitatively similar. The results reported column (6) in Table 3 are obtained using the religious proximity and km of waterways per km^2 of land area.

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