Heterogeneous effects of preferential trade agreements: How does partner similarity matter?

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Abstract

This paper empirically examines whether and how similarity in country characteristics affects the changes in trade flows amongst member countries under a preferential trade agreement (PTA). It demonstrates that accounting for similarity in size, income and location of member countries is important in obtaining unbiased estimates of the trade creation effect of PTAs. Using both a nonparametric stratification and a parametric interaction term approach, we obtain consistent results that the more similar the member countries are in terms of size, income or location, the larger the level *and* the proportion increase in intra-bloc trade under a PTA. Extensive sensitivity analyses that account for potential biases due to self-selection of trade, the extensive margin of trade and omission of trade diversion variables confirm the robustness of our results.

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1 Introduction

Preferential trade agreements (PTAs) have proliferated over the last several decades. Their distribution, however, is highly uneven in terms of partner characteristics. There are noticeably more PTAs amongst countries that are close geographically, and similar in GDP (hereafter size) and in GDP per capita (hereafter income). These simple facts raise two questions: (1) why *ex ante* countries that are more similar in size, income or location[1] have a stronger incentive to form a PTA; and (2) whether *ex post* the partnership between more similar member countries delivers a bigger gain than that between less similar member countries.

The existing theoretical literature has already offered a good deal of explanation of the *ex ante* incentive for similar countries to form a PTA, e.g. see Baier and Bergstrand (2004); Michaely (1998); Krishna (1998) and Levy (1997). On the contrary, there are mixed views on the *ex post* gain from the PTA by those countries. On the one hand, neoclassical trade models suggest that gains from PTAs will be smaller for countries possessing more similar technologies (the Ricardian model) or factor endowments (the Heckscher-Ohlin model). On the other hand, Linder's (1961) hypothesis implies that trade liberalization impacts more on countries of comparable levels of development because of their similar tastes. The monopolistic competition models of Krugman (1980) and Helpman and Krugman (1985) also predict a larger impact of a PTA on intra-industry trade between countries of more similar income levels. Regarding geographical location, Krishna (2003) shows that distance would not affect member countries' welfare changes under a PTA, and Bhagwati and Panagariya (1996) and Panagariya (2000) even find cases of a negative relationship between the two. Given these competing but opposite arguments, it is necessary to look to data to see if there is any evidence that PTAs actually deliver larger gains for member countries that are more alike.

Although there are numerous empirical studies on the trade flows effect of PTAs,[2] the hitherto standard practice is to assume that the PTA effect is homogeneous across all partnerships. As such, they are silent to the second question. Nevertheless, recently a handful of studies notice the insufficiency of such an assumption and start to allow for heterogeneity in their estimations of the PTA effect. Amongst them, Baier and Bergstrand (2004) use a computational general equilibrium (CGE) model to show that gains from a PTA increase when two countries are more similar in size and location, but less similar in income. Yet, as noticed by Clausing (2001), CGE estimates are very sensitive to the assumptions and parameters of the model. Magee (2008), Eicher and Henn (2011), and Eicher et al. (2012) also attempt to account for the heterogeneous effect of PTAs. They estimate the impact of *individual* PTAs on bilateral trade flows for each of the PTAs in their data set using the dummy variable method. Their approach, however, does not pinpoint which dimensions of partner characteristics attribute to the heterogeneous impacts of PTAs.[3] In addition, as the number of PTAs has been increasing dramatically in recent

[1]For reasons to become obvious later, we use the phrases "geographically close" and "locationally similar" interchangeably.

[2]See Magee (2003); Silva and Tenreyro (2006); Baier and Bergstrand (2007); Magee (2008); Helpman et al. (2008); Baier and Bergstrand (2009); Eicher et al. (2012), among others.

[3]For instance, even though Magee (2008) concludes that gains from a PTA are largest for geographically proximate countries and for those with a much larger PTA partner, his conclusion is based on "observing" the differential impacts of different PTAs, rather than on any formal test.

years, it is inefficient to model their effects individually using the dummy variable approach. In fact, Magee (2008) and Eicher et al. (2012) focus only on major PTAs; as such, their results on specific PTAs cannot be generalized to other PTAs.

Against this background, this paper aims to empirically examine whether and how *dissimilarity* in size, income and location between prospective partner countries may affect their gains from forming a PTA.[4] Our empirical work is based on a bilateral panel data set covering 216 countries and more than 330 PTAs over 30 years. Our first empirical strategy is to adopt a stratification approach,[5] which does not impose any parametric assumption on the relationship between the PTA effect and a given measure of dissimilarity. However, under this approach, we can only examine one dimension of dissimilarity at a time. To allow for the possibility that different dimensions of dissimilarity are correlated, our second approach is to incorporate interaction between the PTA measure and the measures of dissimilarity. We consider various models and techniques to estimate heterogeneous PTA effects since previous literature points out various potential sources of biases in the estimation the PTA effect. For each approach, we estimate the heterogeneous PTA effect in a number of models using alternative measures of dissimilarity, alternative estimation techniques or alternative control variables.

Our approach improves on the aforementioned empirical literature on the heterogeneous effect of PTAs. Compared to the CGE modeling approach, our approach imposes much fewer assumptions on the regression models, while also taking advantage of our large data set. Furthermore, by estimating a large number of models with different specifications, we show that any conclusions drawn from this paper are robust to the underlying assumptions of individual models. Compared to the dummy variable approach, our approach is more systematic as we directly test what (and how) partner country characteristics affect the PTA effect. This is achievable because our data set incorporates a large number of PTAs such that there is sufficient variation in dissimilarity in all three dimensions of size, income and location across member countries of different PTAs.

We obtain very consistent results in numerous estimations. First, even in the absence of a PTA, countries that are more similar in size, income or location trade more than those that are less similar. Second, while a PTA has an unambiguous positive effect on intra-bloc trade flows, member countries that are more similar experience a larger *proportional* increase in their trade flows than those that are less similar. The two findings together imply that, in forming a PTA, member countries that are more similar can expect a larger increase in intra-bloc trade flows in both *level* and *proportional* terms. Our results therefore help to settle the theoretical ambiguity on the heterogeneous effect of PTAs on member countries.

The next section describes some stylized facts regarding the distribution of PTAs by country-pairs' characteristics. Section 3 explains the empirical framework. Sections 4 and 5 report the

[4]It may be argued that the capital-to-labor ratio is a 'better' measure than income because it captures differences in technology. We do not consider it for two reasons. Firstly, one of the arguments of why income dissimilarity matters is based on Linders' hypothesis on taste differences, which is a demand side factor. Secondly, using the capital-to-labor ratio requires the construction of the capital stock variable. The most common method to do so is the perpetual inventory method, which in turn requires annual investment data and capital depreciation data. Quality data on investment and depreciation rates is hard to obtain, especially for developing countries.

[5]Our stratification approach can be seen as an application of Heckman and Robb (1985); Heckman et al. (2006) that allows heterogeneous effects of a policy.

results based on the stratification and interaction term approaches, respectively. Conclusions follow in section 6.

2 The stylized facts

Our data cover 216 countries from 1980 to 2010.[6] The data on nominal bilateral trade flows are from the IMF's Direction of Trade Statistics and they are deflated by 2000 U.S. GDP deflator. The data on nominal GDP are from the Penn World Table (PWT). The PTA and GATT/WTO membership data are from the World Trade Organization (WTO). Our measure of PTA includes customs unions and free trade agreements.

Figure 1 shows the distributions of the bilateral import data which are stratified into 10 strata based on country-pairs' dissimilarity. Panels 1(a) and 1(b) show the distributions based on size dissimilarity as measured by $SD_{ijt} \equiv (Y_{it} - Y_{jt})/(Y_{it} + Y_{jt})$, where$Y$ is real GDP measured in PPP-based constant 2000 US dollars. The measure is scale-independent and bounded between -1 and +1, with the value of zero indicating identical sizes between the two countries. Panel 1(a) shows the distribution of all country-pairs while 1(b) shows that of country-pairs with a PTA. The number above each bar is the percentage of observations for each stratum out of the sample. The distribution of country-pairs is more centered in 1(b) than in 1(a), meaning that country-pairs with a PTA tend to be of more similar size compared to those without a PTA.

Panels 1(c) and 1(d) show the distributions based on income dissimilarity measured by $ID_{ijt} \equiv (y_{it} - y_{jt})/(y_{it} + y_{jt})$, where y is real GDP per capita measured in PPP-based constant 2000 US dollars. ID_{ijt} is also bounded between -1 and +1. Once again, the two panels show both the distribution of all country-pairs and those with a PTA . Compared to the case of size dissimilarity, the distribution of country-pairs with a PTA is even more concentrated amongst those of similar income levels.

Lastly, panels 1(e) and 1(f) report the distribution based on locational dissimilarity measured by $LD_{ij} \equiv d_{ij}/d_{max}$,[7] where d_{ij} is the geographical distance in kilometers (km) between the most populated cities in i and j as of 2004, and d_{max} is the maximum distance between any two points on the surface of the earth and is estimated to be 20,037km.[8] LD_{ij} is bounded between 0 and 1. A smaller number for LD_{ij} indicates that the two countries are geographically closer, implying not only lower transportation costs between them, but possibly tighter cultural ties and more similar natural endowments. The distribution in panel 1(f) is much more skewed toward the left than that in 1(e), suggesting that countries with a PTA tend to be geographically more proximate to each other than those without.

To sum up, Figure 1 establishes the stylized facts that countries with a PTA are in general more similar in income and location and, to a lesser extent, in size, as compared to countries without a PTA.

Given that size, income and location dissimilarities of two countries are unlikely to be endogenous to the formation of a PTA, the above stylized facts can be interpreted as that *ex ante* countries that are more similar in these three dimensions have a stronger incentive to form a

[6]Our data are obtained from Christopher Magee's website at http://www.facstaff.bucknell.edu/cmagee/.

[7]Using $log(d_{ij})$ as a measure of locational dissimilarity yields very similar results.

[8]This is based on the estimation that the equatorial radius of the earth is 6,378 km long.

PTA. What is unclear, however, is whether *ex post* the partnership between more similar member countries delivers a bigger gain than that between less similar member countries and, if so, how much bigger. If the gain by more similar member countries is substantially bigger, then it obviously provides a powerful explanation for the stylized facts of PTA formation. Otherwise, it raises the question of what other forces are at work.

There are two ways to measure the "gain from a PTA".[9] The first one is to measure it in terms of the *level* change in trade volume between member countries after the formation of a PTA, and the second one is to measure it in terms of the *proportional* change. We consider the PTA effect to be *homogeneous* if a PTA increases trade flows of member countries by the same *proportions* regardless of their dissimilarity, and *heterogeneous* otherwise.

If, for instance, more similar countries trade more than less similar countries in the absence of a PTA, then even if the PTA effect is homogeneous, the former will still gain more from forming a PTA in level terms though not in proportional terms. On the contrary, if the PTA effect is heterogeneous, then the former may gain more or less in level terms, depending on whether more similar countries experience a larger or smaller proportional change in their trade flows under a PTA than less similar countries. We empirically examine whether the PTA effect is homogenous or heterogeneous in member countries dissimilarity in what follows.

<Insert Figure 1 here>

3 The modeling framework

The most commonly used empirical framework to measure the PTA effect is the gravity equation as in (1):

$$ln(T_{ijt}+1) \quad = \quad \mathbf{X}_{ijt}\alpha + \beta PTA_{ijt} + \mu_t + \omega_{ij} + u_{it} + v_{jt} + \epsilon_{ijt} \tag{1}$$

where T_{ijt} is imports by country i from country j at time t; PTA_{ijt} is a dummy and equal to one if i and j are common members of at least one PTA at time t and zero otherwise[10]; and $\mathbf{X}$ is a vector of other determinants, e.g. GDP, GDP per capita (income), distance, common language, common colony, border contiguous, common legal origin, and GATT/WTO membership; μ_t represents any unobserved global trend in trade and aggregate shocks in each year; ω_{ij} is country-pair fixed effects (CPFEs), which capture any time-invariant country-pair heterogeneity such as cultural, historical or political ties that may affect the likelihood of a PTA; u_{it} and v_{jt} are, respectively, importer-time and exporter-time fixed effects (or in general country-time fixed effects, CTFEs), which capture any time-varying country heterogeneity such as multilateral resistance (Anderson and van Wincoop, 2003; Baldwin and Taglioni, 2006; Subramanian

[9]Due to data limitations, most empirical studies focus on the change in bilateral trade flows rather than on the change in welfare to get the implied welfare effect of PTA. Magee (2008) provides an alternative method to estimate the trade creation (TC) effect of PTAs, which is closer to Viner's (1950) concept of TC.

[10]This means that if the two countries are part of more than one PTA at time t, we only count it as one because an extra PTA is redundant as far as the same two countries are concerned.

and Wei, 2007), business cycles or policy changes (Baier and Bergstrand, 2007; Magee, 2008). Following Liu (2009) and Roy (2011), $ln(T_{ijt}+1)$ instead of $ln(T_{ijt})$ is used to circumvent the problems of having zero observations. We also include a dummy in the model for the zero trade flows observations as in Behrens et al. (2010).

The literature suggests β, which indicates the change in intra-bloc trade, to be positive. This positive PTA effect on intra-bloc trade is commonly considered as the empirical equivalence of the trade creation (TC) effect in the theoretical literature. Equation (1) omits trade diversion (TD), which is typically measured as the number of 'other' PTAs signed by country i and some third country $k \neq j$ at time t: $OPTA_{ijt} = \sum_{k\neq j} PTA_{ikt}$. However, the sum of PTA_{ijt} and $OPTA_{ijt}$ is equal to the total number of PTAs signed by country i at time t and is therefore j-invariant. As a result, the inclusion of $OPTA_{ijt}$ causes perfect multicollinearity with importer-time FEs. Previous studies tend to omit TD to avoid the multicollinearity problem when controlling for CTFEs (e.g. Magee, 2008; Eicher et al., 2012). This practice can be justified since the TD effect is often found to be neither statistically significant nor economically important (e.g. Magee, 2008). On the contrary, it is found that controlling for CTFEs is crucial in obtaining unbiased coefficient estimates. (see e.g. Magee (2008); Eicher et al. (2012)) Therefore, in this paper we follow the typical practice in the literature, omitting the trade diversion term while controlling CTFEs. [11][12]

3.1 The average effect of PTAs on bilateral trade flows

In this section, we replicate some benchmark estimates of the TC effect as in previous studies. The results are reported in Table 1. All the variables of interest are significant at the 1% level. With time fixed effects (TFEs) only, as shown in column (1), a PTA is estimated to increase trade between member countries on average by 280% ($e^{1.33}$=3.80). The impact, however, shrinks substantially to 63% in column (2) when CPFEs are included. This implies that unobserved time-invariant heterogeneity that correlates with both the formation of a PTA and bilateral trade flows tends to bias the PTA coefficient upward. We further include CTFEs in columns (3) to control for multilateral resistance and country-specific aggregate shocks. The coefficient on PTA moderates further to 51% as a result.

As shown in column (1), location dissimilarity (LD_{ij}), in accordance with the gravity model, is of a negative sign. The results suggest that, other things being equal, countries that are $200km$ (i.e. 1% of d_{max}) farther apart will see their trade flows to drop by nearly .6%. The variable is omitted in the other columns due to the inclusion of CPFEs.

In column (4) we include the absolute measures of size dissimilarity (ASD_{ijt}) and income dissimilarity (AID_{ijt}). The point estimate of the PTA coefficient is reduced very slightly as compared to column (3). The two dissimilarity measures are of a negative sign and statistically significant. While the results suggest that an increase in size or income dissimilarity between two

[11]The Pseudo-Poisson-Maximum-Likelihood (PPML) method suggested by Silva and Tenreyro (2006) is also widely used in the studies of the PTA effect, but it is computationally challenging to simultaneously control for CPFEs and CTFEs.

[12]We have also included the TD term in the estimations using the biennial CTFEs approach as in Cheong et al. (2012). The results are reported in Appendix C. The findings reported in the main text remain the same qualitatively as well as quantitatively.

countries will reduce their trade flows, one cannot interpret the coefficients of the dissimilarity measures as their marginal effects. This can be explained using a highly simplified gravity equation (2), which has only one measure of dissimilarity.

$$ln(T_{ij}) = \alpha_1 lnY_i + \alpha_2 lnY_j + \alpha_3 \frac{|Y_i - Y_j|}{Y_i + Y_j} + \mathbf{X}_{ij}\alpha + \epsilon_{ij} \tag{2}$$

For example, in the scenario of $Y_i > Y_j$, (2) becomes (3)

$$ln(T_{ij}) = \alpha_1 lnY_i + \alpha_2 lnY_j + \alpha_3 \frac{Y_i - Y_j}{Y_i + Y_j} + \mathbf{X}_{ij}\alpha + \epsilon_{ij} \tag{3}$$

The coefficient α_3 cannot be interpreted as "the marginal effect of an increase in size dissimilarity on trade flows keeping other things constant" like other variables. This is because, for size dissimilarity to change, either Y_i or Y_j has to change and therefore the "keeping other things constant" clause is violated.[13] On the other hand, it is appropriate to compute the marginal effect of Y_i on T_{ij}, which is equal to $\frac{\partial T_{ij}/T_{ij}}{\partial Y_1/Y_1} = \alpha_1 + \alpha_3 \frac{2Y_iY_j}{(Y_i+Y_j)^2}$. The term α_1 represents the own effect of a larger Y_i, while $\alpha_3 \frac{2Y_iY_j}{(Y_i+Y_j)^2}$ represents the additional effect due to an increase in size dissimilarity between i and j. Since $\frac{2Y_iY_j}{(Y_i+Y_j)^2} > 0$, if $\alpha_3 < 0$, then the additional effect on T_{ij} due to an increase in size dissimilarity will be unambiguously negative, but its magnitude depends on the initial sizes of the two countries. In other words, although α_3 cannot be interpreted as the marginal effect of a change in size dissimilarity on bilateral trade flows, its sign can still tell us whether country-pairs of more similar size are expected to trade more.

Applying this logic to column (4), the negative signs of ASD and AID and their statistical significance indicate that size and income dissimilarity, respectively, between two countries have unambiguous negative impacts on their bilateral trade flows. In columns (5) and (6) we consider country-pairs without and with a PTA separately. In both cases, size and income dissimilarity continue to have negative impacts on bilateral trade flows, but the impacts are significantly larger for countries with a PTA than those without.

To summarize, countries that are more similar in size, income or location are found to have a larger trade volume. This means that, even if the TC effect of PTAs is homogenous, countries that are more similar will gain more in level terms because of their bigger pre-PTA trade volume. Yet, if the TC effect is heterogeneous in similarity, then the standard estimates of the change in intra-bloc trade as in the previous section is merely an average effect of trade creation. More importantly, if the TC effect is increasing in similarity, then countries that are more similar will gain more in proportional terms and, thus, even more in level terms. We test whether this is the case in the next two sections.

<Insert Table 1 here>

[13] The argument remains valid when we include CTFEs and drop Y_{it} and Y_{jt} from the gravity equation, as the latter two variables are merely absorbed in the former variable.

4 The stratification approach

Our first empirical strategy is to adopt a stratification approach to avoid presuming any prior relationship between the TC effect and member countries' dissimilarity. Under this approach, we stratify the variable PTA_{ijt} in (1) into 10 PTA^{p}_{ijt} variables ($p = 1,2,3...,9,10$) based on a particular measure of dissimilarity, so that each PTA^{p}_{ijt} can have a different coefficient. The resulting gravity equation is:

$$ln(T_{ijt}+1) \quad = \quad \mathbf{X}_{ijt}\alpha + \sum_{p=1}^{10}(\beta^{p} PTA^{p}_{ijt} + \gamma^{p} D^{p}_{ijt}) + \omega_{ij} + u_{it} + v_{jt} + \epsilon_{ijt} \tag{4}$$

where $PTA^{p}_{ijt} = PTA_{ijt} \cdot D^{p}_{ijt}$, and D^{p}_{ijt} is a dummy variable that takes a value one if the observation belongs to centile p (or pth stratum) and zero otherwise.[14]

The inclusion of D^{p}_{ijt} as an independent regressor in (4) is to stratify observations with $PTA_{ijt} = 0$ in the same way as those with $PTA_{ijt} = 1$, such that the coefficient β^{p} can be interpreted as the *within group p* differences in trade flows between those with and those without a PTA.

Besides stratifying PTA_{ijt} into different centiles based on a particular measure of dissimilarity, we also consider stratifying it into different groups based on the *actual value* of the measure. The main difference is that in the former, each centile has the same number of observations, but the change in the degree of dissimilarity from one bin to another may not be constant; while in the latter, each group may have a different number of observations, but the change in the degree of dissimilarity from one bin to another is kept constant. We refer to the former as "centile stratification" and the latter as "value stratification".

We use five different stratifiers to represent the dissimilarity of country-pairs. Besides SD_{ijt}, ID_{ijt} and LD_{ij} introduced earlier, we also consider absolute size dissimilarity: $ASD_{ijt} \equiv |Y_{it} - Y_{jt}|/(Y_{it} + Y_{jt})$,[15] and absolute income dissimilarity: $AID_{ijt} \equiv |y_{it} - y_{jt}|/(y_{it} + y_{jt})$.

As ASD, AID and LD are constructed to be increasing in p, if the hypothesis that the TC effect is larger for more similar member countries is valid, then we should observe the coefficient β^{p} to be decreasing in p .

The non-absolute measures, SD and ID, allow the PTA effect to be asymmetric. For instance, the TC effect may vary depending on whether the importer is bigger than the exporter, or the other way around. If the TC effect is larger for member countries of similar sizes or incomes, then we should observe β^{p} to be an inverse-U shape function of p when these non-absolute stratifiers are used.

[14] See Appendix A for the details on D^{p}_{ijt}.

[15] Helpman (1987) and Hummels and Levinsohn (1995) suggest an alternative size similarity measure, $1 - (\frac{Y_i}{Y_i+Y_j})^2 - (\frac{Y_J}{Y_i+Y_j})^2 = \frac{2Y_iY_j}{(Y_i+Y_j)^2}$. Their measure is actually a monotonic transformation of ASD. Using their measure does not change our findings.

4.1 Stratification based on size dissimilarity

Table 2 reports the estimation results for β^p with the stratification of PTA_{ijt} being based on size dissimilarity. What distinguishes between the four columns is whether the absolute or non-absolute size dissimilarity measure is used, and whether the stratification is based on the centile or the value. The PTA_{ijt} coefficients in all four columns are statistically significant at the 1% level and the signs are all positive. The results are illustrated in Figure 2, in which the solid line depicts the marginal effects of a PTA on bilateral trade flows and the dashed line represents the 95% confidence interval.

Figure 2(a) shows that as the member countries become more dissimilar size-wise, the impact of a PTA on intra-bloc trade declines significantly. A PTA increases the trade flows between the most similar member countries in the first centile by 63%, but the impact drops to 16% for those in the ninth centile. This is in line with the findings in Baier and Bergstrand (2004). Moreover, our result reveals the linear relationship between the PTA effect and size dissimilarity, confirming the heterogeneous effect of PTAs as shown in Magee (2008), Eicher and Henn (2011) and Eicher et al. (2012).

The use of value stratification, as shown in Figure 2(b) gives a similar conclusion. However, it also indicates that the TC effect of a PTA falls sharply when ASD is equal to .75 or higher. For instance, among PTA member countries in 1995, GDP of Italy was about seven times bigger than GDP of Denmark so that the ASD value for this pair was about .75.[16] GDP of UK was comparable to GDP of Italy and the value for this pair was about .01. Based on our results, if the PTA effect is heterogeneous only in size dissimilarity, the TC effect of a PTA between UK and Italy is predicted to be 1.5 times larger than that between Italy and Denmark.

In Figure 2(c), SD instead of ASD is used for centile stratification. The TC effect is at its peak at the seventh centile and declines monotonically from there onward. A PTA increases intra-bloc trade by as much as 66% for member countries in the seventh centile, compared to about 11% and 28% for the first and tenth centiles, respectively.

Lastly, in Figure 2(d), SD is used for value stratification. Again, we obtain an inverse U-shaped relation between the intra-bloc trade change and size dissimilarity. The marginal effect of a PTA is largest when the value of SD lies between -0.2 and .4.

<Insert Table 2 here>

<Insert Figure 2 here>

4.2 Stratification based on income dissimilarity

Table 3 reports the estimation results of stratifying PTA based on income dissimilarity. Most of the PTA coefficients are statistically significant at the 1% level with a few exceptions, such as PTA_{90} in column (1) and PTA_{10} in column (3). All coefficients are of a positive sign. The marginal effects of a PTA are illustrated in Figure 3.

In Figure 3(a), where AID is used for centile stratification, the TC effect of a PTA becomes smaller as member countries become more dissimilar income-wise. The TC effect is largest at

[16]The size ratio is equal to $(1+ASD)/(1-ASD)$.

the first centile (67%) and lowest at the ninth centile (5%), with a nine-fold difference between them.

In Figure 3(b), AID is used for value stratification. Again, the coefficients show a decreasing trend as the value of stratifier increases. This result is in contrast to Baier and Bergstrand (2004), which shows that a larger difference in capital-labor ratio (a proxy for income dissimilarity) between two countries leads to larger PTA effects. When AID is equal to .1 to .2, i.e. the member countries are of very similar incomes, the impact of a PTA on their bilateral trade is largest (69%). If $AID = .9$, i.e. the income level of one country is 19 times larger than that of the other countries, the impact decreases to 14%. For instance, in 1995 GDP per capita of Germany ($33,595) was 19 times larger than that of Bulgaria ($1,692) so that the AID value for this pair was about .9, while GDP per capita of Germany was comparable to that of Austria ($32,578) and the AID value for this pair was about .02. This implies that the TC effect of a PTA between Germany and Austria is expected to be 1.8 times larger than that between Germany and Bulgaria.

In Figure 3(c), ID is used for centile stratification. The inverse U-shaped curve with a maximum point around the middle confirms the hypothesis that the TC effect is stronger for countries of more similar income levels. A PTA increases intra-bloc trade by the maximum 68% at the fourth centile, diminishing to 15% at the last centile.

Lastly, in Figure 3(d) ID is used for value stratification. Again, we obtain an inverse U-shaped curve with a maximum point around the middle. If ID lies between -0.2 and 0, a PTA is expected to increase intra-bloc trade by as much as 70%; however, if ID enlarges to .9, i.e. when the importing country is 19 times as rich as the exporting country, the effect declines to about 25%.

<Insert Table 3 here>

<Insert Figure 3 here>

4.3 Stratification based on location dissimilarity

In this section, we stratify PTA based on location dissimilarity. The results are reported in Table 4 and the corresponding marginal effects are illustrated in Figure 4. Unlike the cases of size and income dissimilarity, far more estimated coefficients are statistically insignificant.

In Figure 4(a) LD is used for centile stratification. The TC effect of PTA declines rapidly from about 70% at the first centile to zero at the fourth centile. One possible explanation for this is that as transportation and information costs increase with distance, the percentage change in total transaction cost as a result of tariff or other barrier reduction under a PTA declines with distance. There seems to be a revival of the TC effect at the ninth centile, which consists of country-pairs that are the second most far apart. One possible explanation is that if a PTA is formed between a country in the northern hemisphere and a country in the southern hemisphere it may stimulate large inter-industry trade.[17] However, the point estimation of the effect for that centile is very imprecise, as reflected in the large standard errors.

[17] Country pairs at the ninth centile include Chile-Austria, Chile-Denmark, Chile-Norway, Chile-Sweden, Chile-Finland, Chile-Greece, Chile-Bulgaria, Chile-Czech, Chile-Slovak, Chile-Estonia, Chile-Latvia, Chile-Hungary, Chile-Lithuania, Chile-Poland, Chile-Romania, Chile-Cyprus, Israel-Mexico, and US-Oman.

In Figure 4(b), value stratification is used. Again, the TC effect falls rapidly from 77**%** for the first group to zero by the fourth group. The TC effect is positive and statistically significant only up to the third group. The cutoff distance for the third group is about 6,010km, and the group includes country pairs such as the US and Peru, Norway and Canada, and Portugal and Surinam.[18]

The impreciseness of the point estimation for the higher centiles could be attributed to the small number of PTA pairs in those centiles. To examine if this is the case, we stratify our sample in such a way that each centile has the same number of country pairs with PTAs. The results are reported in the last column of Table 4 and illustrated in Figure 4(c). The confidence interval is wider for the lower centiles because they now have relatively fewer country pairs without PTAs. Despite that, there is a sufficiently large number of observations in each centile to identify the downward sloping relationship between the TC effect and distance, as one would expect.

Overall, the increase in location dissimilarity leads to a smaller effect of PTA as found in Baier and Bergstrand (2004) and Magee (2008), and the effect can be close to zero if the two countries are sufficiently far apart from each other.

<Insert Table 4 here>

<Insert Figure 4 here>

4.4 Discussion

The stratifaction approach has produced some strong results for size and income dissimilarity. country-pairs that are more similar in size or income experience a larger increase in their bilateral trade than less similar country-pairs in both *level* and *proportion* terms. Notwithstanding, even for the most dissimiliar country-pairs, the TC effect is still significantly bigger than zero. The TC effect of a PTA is also monotically decreasing as country-pairs become geographically farther apart. When the distance is sufficiently large, the TC effect becomes indiscernible. Beyond that point, it is possible that the TC effect may stay zero, but the estimation becomes so imprecise that it is hard to make concrete inference. Yet, interestingly, beyond the distance at which the TC effect first becomes zero, two countries are so far apart that they typically are on different continents. These results clearly demonstrate the effect of a PTA is very much subject to the tyranny of distance.

5 The interaction term approach

A drawback of the stratification approach is that it may lead to biased estimation if there is correlation among different dimensions of dissimilarity when PTA is only stratified by one factor at a time.[19] For instance, if closer countries have similar natural endowments and, thus, similar

[18]The cutoff distance for the fourth group is about 8,015km and the group includes country pairs such as the US and Italy, Italy and South Africa, the Netherlands and Jamaica, and Norway and Japan.

[19]The correlations between different measures of dissimilarity range from .01 to .45. Details are reported in Appendix B.

incomes, then the observed heterogeneity of the PTA effect on locational dissimilarity might be partly due to income dissimilarity. Although in principle this problem can be dealt with by stratifying PTA with multiple criteria simultaneously, such a procedure is rather burdensome. Instead, we incorporate interaction terms between PTA and the dissimilarity measures into a generalized gravity model.

In addition, our results in the previous section are based on a log-linear gravity model. However, as our dependent variable includes a number of zero obseravation, the log-linear specification may produce biased estimates if we do not consider self-selection. Thus, in this section we extend the log-linear model to a generalized one that accounts for self-selection.[20]

5.1 Absolute measures of dissimilarity

We first modify (1) by incorporating interaction terms between the PTA term and the absolute size dissimilarity, absolute income dissimilarity, and location dissimilarity terms. We also account for self-selection with additional regressors:

$$\begin{aligned} ln(T_{ijt}) = \; & \mathbf{X}_{ijt}\alpha + \beta_1 PTA_{ijt} + \beta_2 PTA_{ijt} \cdot ASD_{ijt} + \beta_3 PTA_{ijt} \cdot AID_{ijt} \\ & + \beta_4 PTA_{ijt} \cdot LD_{ij} + \beta_5 PTA_{ijt} \cdot LD_{ij}^2 + \beta_6 ASD_{ijt} + \beta_7 AID_{ijt} \\ & + \delta \cdot \hat{IMR}_{ijt} + \omega_{ij} + u_{it} + v_{jt} + \epsilon_{ijt} \end{aligned} \tag{5}$$

where $\hat{IMR}_{ijt}$ is a first stage estimate of the inverse mills ratio .

The regression includes the interaction between PTA_{ijt} with the squared term of LD_{ij} because the stratification results indicate that the TC effect of PTA could be a non-linear function of location dissimilarity. The inclusion of ASD_{ijt} and AID_{ijt} as individual regressors in (5) is to avoid their interaction terms from picking up their own effects. $\hat{IMR}_{ijt}$ is added as an additional regressor to account for self-selection. Model (5) allows us to test how one dimension of dissimilarity affects the responsiveness of bilateral trade flows to the formation of a PTA, keeping the other dimensions of dissimilarity constant.

The effect of a PTA on T_{ijt} is given by:

$$\frac{\Delta(T_{ijt}+1)/(T_{ijt}+1)}{\Delta PTA_{ijt}} = TC_{ijt} = exp(\beta_1 + \beta_2 ASD_{ijt} + \beta_3 AID_{ijt} + \beta_4 LD_{ij} + \beta_5 LD_{ij}^2) - 1 \tag{6}$$

and the marginal effect of, say, ASD_{ijt} on TC_{ijt} is given by:

$$\frac{\partial TC_{ijt}}{\partial ASD_{ijt}} = \beta_2 exp(\beta_1 + \beta_2 ASD_{ijt} + \beta_3 AID_{ijt} + \beta_4 LD_{ij} + \beta_5 LD_{ij}^2) \tag{7}$$

Our results from section 4 suggest $\beta_2 < 0$, $\beta_3 < 0$, and $\beta_4 < 0$.

Table 5 reports the estimation results. We first focus on the log-linear results in column (1). All signs of the coefficients are consistent with the stratification estimations, and they are statistically significant at the 1% level except for $PTA \cdot ASD$, which is significant at the 5% level.

[20]Details for implementing the Heckman (1979) procedure are provided in Appendix D.

It is shown that while a PTA increases intra-bloc trade, the effect is smaller for country-pairs that are more dissimilar in size, income, or location.

The standalone terms of ASD and AID are also significant at the 5% and 1% level respectively, confirming the findings in Table 1 that even in the absence of PTAs, countries trade more with more similiar counterparts. The magnitudes of their coefficients are also fairly similar to those in Table 1.

The lower half of the table reports various marginal effects evaluated at the mean values of $ASD\,(.7)$, $AID\,(.59)$, $LD\,(.40)$, and $LD^2\,(.22)$. At these values, a PTA is expected to increase intra-bloc trade by 16.6%.

Consider two countries taking the mean values of the dissimilarity measures, i.e. one country is 5.67 times the size of, 3.88 times as rich as, and 8,015km away from the other. If ASD increases by .01 (i.e. from .7 to .71) as the originally bigger country has grown to 5.9 times the size of the other one, other things equal, the results in Table 5 suggest that the TC effect on these two countries will be moderated by .19 percentage points to 16.4%. Similarly, if AID increases by .01 as the originally richer country has become four times as rich as its counterpart, then it will lower the TC effect by .31 percentage points to 16.3%. Lastly, if LD increases by .01, i.e. they are now 8,215 km apart, the TC effect will be moderated by .8 percentage points to 15.8%.

Furthermore, at the mean values of the other two dissimilarity measures, PTAs cease to have any TC effect when: ASD increases to 0.78 (i.e. one country is 8 times the size of the other one), or AID increases to 0.64 (i.e. one country is 4.6 times richer than the other one), or LD increases to 0.42 (i.e. two countries are 8416km apart). Amongst these linear projections, the one for LD is particularly worth noticing. This is because, first, the results from Section 4 suggest that the PTA effect could vanish in the case of sufficiently large location dissimilarity, but not of large size or income dissimilarity, and second, the depletion point of 0.42 is quantitatively similar to the value stratification results in Table 4.

The marginal effect of dissimilarity on TC, however, is not a complete measure of the impact of dissimilarity on bilateral trade flows under a PTA. This is because, as established previously, country-pairs that are more similar trade more even without a PTA. Therefore, there are two channels through which dissimilarity impacts on bilateral trade flows under a PTA: one is through the initial, pre-PTA trade flows, and the other one is through the TC effect of PTAs. To disentangle these two effects, we make use of the fact that:

$$\frac{\partial^2 (T_{ijt}+1)/(T_{ijt}+1)}{\partial ASD_{ijt} \partial PTA_{ijt}} = \frac{\Delta (T_{ijt}+1)/(T_{ijt}+1)}{\Delta PTA_{ijt}} \frac{\partial (T_{ijt}+1)/(T_{ijt}+1)}{\partial ASD_{ijt}} + \frac{\partial TC_{ijt}}{\partial ASD_{ijt}} \tag{8}$$

The left hand side of (8) is the the cross marginal effect of ASD and PTA on $(T+1)$, and is a complete measure of the impact of dissimilarity on bilteral trade flows under a PTA. The first term on the right hand side is a product of the impact of PTA on trade flows and the impact of ASD on the initial trade flows. Since more similar countries trade more initially, they would have gained more even if the PTA effect on trade flows were *homogeneous*. The first term captures this interaction effect between ASD and PTA through initial trade flows. On the other hand, when the PTA effect is *heterogeneous*, then even if all country-pairs are of the same intital bilateral trade flows, more similar ones stand to gain more from forming a PTA. The second term captures this interaction effect between ASD and PTA through TC.

Using the results from Table 5, the cross marginal effect of ASD and PTA on $(T+1)$ can be computed as $-.166 \times .192 - .189 = -.22$, i.e. a pair of countries with a size difference of 5.67 times (and mean income and location dissimilarities) can expect to have .22% more trade flows under a PTA than a pair of countries with a size difference of 5.9 times. Out of this .22% extra gain, .03% is due to the fact that they have larger initital trade flows, and .19% is due to the fact that they enjoy a larger TC effect under a PTA.

Likewise, the cross marginal effects of AID and PTA, and of LD and PTA are equal to, respectively, -.34 ($=-.166 \times .195 - .312$) and -.90 ($=-.166 \times .56 - .804$), where -.56 is the estimated coefficient for LD in column (1) of Table 1.

These decompositions indicate that the impact of dissimilarity on bilateral trade flows under a PTA is predominately due to the impact of dissimarlity on TC, instead of its impact on initial trade flows.

Column (2) reports the results from the Heckman (1979) procedure. The qualitative results remain the same as in the log-linear model, but a noticeable quantitative difference appears: in the Heckman estimation, as the estimates of the interaction terms with LD are much larger, the marginal effects of LD on TC in absolute terms are bigger.

<Insert Table 5 here>

<Insert Table 6 here>

5.2 Non-absolute, asymmetric measures of dissimilarity

A limitation of (5) is that it imposes symmetry on the impacts of dissimilarity, e.g. the impact of $SD_{ijt} = 0.1$ is restricted to be the same as that of $SD_{ijt} = -0.1$. In this section, we modify (5) into (9) to allow for asymmetric impacts:

$$\begin{aligned} ln(T_{ijt}+1) \quad = \quad & \mathbf{X}_{ijt}\alpha + \beta_1 PTA_{ijt} + \beta_2 PTA_{ijt} \cdot SDP_{ijt} + \beta_3 PTA_{ijt} \cdot SDN_{ijt} \\ & + \beta_4 PTA_{ijt} \cdot IDP_{ijt} + \beta_5 PTA_{ijt} \cdot IDN_{ijt} + \beta_6 PTA_{ijt} \cdot LD_{ij} \\ & + \beta_7 PTA_{ijt} \cdot LD^2_{ij} + \beta_8 SDP_{ijt} + \beta_9 SDN_{ijt} + \beta_{10} IDP_{ijt} + \beta_{11} IDN_{ijt} \\ & + \delta \cdot IM\hat{R}_{ijt} + \omega_{ij} + u_{it} + v_{jt} + \epsilon_{ijt} \end{aligned} \tag{9}$$

where $T_{ijt} > 0$ and SDP is set to be SD when $SD > 0$ and zero otherwise, and SDN is set to be $-SD$ when $SD < 0$ and zero otherwise, and likewise for IDP and IDN (here "N" stands for negative, "P" stands for positive). We set $SDN = -SD$ when $SD < 0$ so that its coefficient is expected to have the same, negative sign as that of SDP.[21]

Table 6 reports the estimation results. The results for the standalone dissimilarity measures are omitted to save space. Again, we first focus on the log-linear model. The interaction terms with SDP, SDN, IDP, and IDN are of a negative sign, confirming the previous result that the

[21] A model using non-absolute, symmetric measures is also esimated in Appendix E and the qualitative results remain the same.

TC effect is largest when the country-pairs are of the same size and income. However, there are noticable asymmetries in the results. The coefficient of $PTA \cdot SDP$ is relatively small and statistically insignificant, while that of $PTA \cdot SDN$ is relatively large and statistically significant at the 5% level. This means that size dissimilarity has a discernible negative effect on TC only if the exporting country is larger than the importing country. On the contrary, the coefficients of both $PTA \cdot IDP$ and $PTA \cdot IDN$ are statistically significant at the 1% and 5% level, respectively, implying that the TC effect decreases in the income dissimilarity of member countries regardless whether the importing or the exporting country is the richer one. Nevertheless, the point estimate for the coefficient of $PTA \cdot IDP$ is bigger than that of $PTA \cdot IDN$ by more than 50%. The coefficients of $PTA \cdot LD$ and $PTA \cdot LD^2$ are statistically significant at the 1% level and the magnitudes are similar to those in Tables 5 and 10. We continue to obtain similar qualitative results using the Heckman (1979) procedure. A noticable difference, however, is that $PTA \cdot IDP$ is insignificant but of the same sign and again the marginal effects of LD on TC are far bigger.

5.3 Discussion

The results from the interaction approach confirm the results from the previous sections. Overall, the more similar the country-pairs, the larger their bilateral trade flows even in the absence of a PTA, and the larger the TC effect of a PTA. The decomposition exercise shows that the effect of dissimilarity on the gain from a PTA mostly comes from its impact on TC rather than from its impact on initial trade flows. Notwithstanding, it remains valid to conclude that a PTA leads to larger *level* as well as *proportional* changes in bilateral trade flows between more similar country-pairs than less similar ones.

The results from absolute and non-absolute dissimilarity measures are very consistent with each other. In particular, results from both measures confirm that the TC effect of PTAs are the largest when country-pairs are of the same size, income and location.

On the one hand, our results are broadly consistent with those in Baier and Bergstrand (2004) or Magee (2008) where the impact of a PTA on intra-bloc trade declines significantly as the member countries become more dissimilar size-wise and location-wise. As for the impact of income dissimilarity, our finding is opposite to the implication of Baier and Bergstrand (2004), which shows larger income dissimilarity leads to larger PTA effects. On the other hand, our results from the non-absolute, asymmetric dissimilarity measures give deeper insight on the effect of size and income dissimilarity beyond the existing literature. Our results suggest that size dissimilarity has a discernible negative effect on TC only when the importing country is smaller than the exporting country. This hints that the demand capacity of the importing country constitutes the constraint on TC, whereas the supply capacity of the exporting country is less of a factor. Furthermore, income dissimilarity has a noticeably stronger negative effect on TC when the importing country is richer than the exporting country, than when the exporting country is richer than the importing country. This may be due to the possiblity that a poorer country does not have the capacity to produce high-end consumer and producer goods demanded by a richer country, while the latter has the capacity to produce such goods for the former.

6 Conclusions

This paper investigates whether countries that are more similar in size, income or location will gain more from a PTA. We apply the stratification approach to allow full-flexibility of the relationship between the PTA effect and member countries characteristics, as well as the interaction term approach to consider different member countries' characteristics simultaneously. This paper deals with the endogeneity problems arising from the simultaneity of PTA formation and trade flows and from omitted variables by controlling for country-pair fixed effects, country-time fixed effects, self-selection and the extensive margin of trade. Results obtained from the two approaches are highly consistent and robust to potential biases due to the endogeneity problems.

We find evidence that, first, countries that are more similar in size, income or location trade more even without a PTA; and second, a PTA has a larger proportional effect on the trade flows between member countries that are more similar in each of these three dimensions. We also find evidence that the second factor dominates the first one in determining the total effect of dissimilarity on bilateral trade flows between two countries under a PTA. Together the two factors unambiguously imply that countries that are more similar will gain more from a PTA in both level and proportional terms than their less similar counterparts. This finding helps to explain the stylized fact that more PTAs have been formed amongst countries that are more similar in size, income or location. By confirming the significant heterogeneity in the effect of PTAs, our finding also indicates significant bias in the existing studies that treat the PTA effect as homogeneous.

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Table 1: The average effect of PTAs on bilateral trade flow

	(1)	(2)	(3)	(4)	(5)	(6)
PTA_{ijt}	1.334***	.491***	.412***	.406***		
	(.041)	(.025)	(.027)	(.027)		
$LD_{ij} \equiv d_{ij}/d_max$	-.560***					
	(.015)					
$ASD_{ijt} \equiv \frac{\lvert Y_{it}-Y_{jt}\rvert}{Y_{it}+Y_{jt}}$				-.202***	-.193***	-.431***
				(.032)	(.032)	(.136)
$AID_{ijt} \equiv \frac{\lvert y_{it}-y_{jt}\rvert}{y_{it}+y_{jt}}$				-.215***	-.177***	-.797***
				(.028)	(.029)	(.117)
Controls	A	B	C	C	C	C
TFEs	Yes	Yes	Yes	Yes	Yes	Yes
CPFEs	No	Yes	Yes	Yes	Yes	Yes
CTFEs	No	No	Yes	Yes	Yes	Yes
Num of Obs	861,969				811,997	49,972
Use of Obs	all	all	all	all	PTA=0 only	PTA=1 only

Note: Sample year from 1980 to 2010. *, **, *** are 10%, 5%, 1% significance levels. Cluster (country-pairs) robust standard errors are reported in parentheses. "A" includes $\ln(distance_{ijt})$, $\ln(Y_{it})$, $\ln(Y_{jt})$, commom language dummy, common colony dummy, shared borders, common legal origin dummy, and WTO membership (for both of pair) dummy. "B" includes $\ln(Y_{it})$, $\ln(Y_{jt}$ and WTO membership dummy). "C" has WTO membership dummy variable. Y represents GDP measured in constant 2000 US dollars. Column (5) uses only the data of country-pairs with no PTA and Column (6) uses only the data of country-pairs with PTA.

Table 2: The coefficient estimate of PTA by size dissimilarity

Estimation model	(1)	(2)	(3)	(4)
PTA_{10}	.491***	.541***	.107***	.293***
	(.052)	(.059)	(.071)	(.043)
PTA_{20}	.499***	.457***	.350***	.343***
	(.045)	(.056)	(.060)	(.053)
PTA_{30}	.479***	.491***	.345***	.420***
	(.045)	(.053)	(.052)	(.061)
PTA_{40}	.428***	.502***	.401***	.485***
	(.044)	(.049)	(.051)	(.058)
PTA_{50}	.377***	.467***	.491***	.505***
	(.046)	(.047)	(.050)	(.060)
PTA_{60}	.331***	.465***	.494***	.486***
	(.049)	(.054)	(.052)	(.062)
PTA_{70}	.363***	.449***	.509***	.509***
	(.055)	(.048)	(.054)	(.060)
PTA_{80}	.294***	.398***	.374***	.503***
	(.055)	(.047)	(.058)	(.060)
PTA_{90}	.152***	.338***	.334***	.484***
	(.066)	(.045)	(.068)	(.057)
PTA_{100}	.201***	.267***	.245***	.311***
	(.079)	(.038)	(.084)	(.050)
PTA weight	$\frac{\lvert Y_i - Y_j \rvert}{Y_i + Y_j}$	$\frac{\lvert Y_i - Y_j \rvert}{Y_i + Y_j}$	$\frac{Y_i - Y_j}{Y_i + Y_j}$	$\frac{Y_i - Y_j}{Y_i + Y_j}$
stratification	centile	value	centile	value
	Number of observations=861,969			

Note: Sample year from 1980 to 2010. *, **, *** are 10%, 5%, 1% significance levels. Cluster (country-pairs) robust standard errors are reported in parentheses. All results are obtained by including TFEs, CTFEs, and CPFEs. Y represents GDP measured in constant 2000 US dollars.

Table 3: The coefficient estimate of PTA by income dissimilarity

Estimation model	(1)	(2)	(3)	(4)
PTA_{10}	.515***	.522***	.138	.294***
	(.047)	(.050)	(.130)	(.074)
PTA_{20}	.466***	.520***	.325***	.359***
	(.041)	(.045)	(.062)	(.053)
PTA_{30}	.446***	.454***	.416***	.492***
	(.040)	(.043)	(.052)	(.052)
PTA_{40}	.508***	.450***	.518***	.483***
	(.043)	(.042)	(.046)	(.048)
PTA_{50}	.385***	.515***	.500***	.529***
	(.043)	(.043)	(.045)	(.049)
PTA_{60}	.353***	.440***	.504***	.522***
	(.045)	(.045)	(.045)	(.049)
PTA_{70}	.280***	.380***	.453***	.422***
	(.047)	(.044)	(.048)	(.050)
PTA_{80}	.308***	.307***	.341***	.468***
	(.053)	(.044)	(.051)	(.053)
PTA_{90}	.045	.316***	.277***	.337***
	(.086)	(.047)	(.054)	(.052)
PTA_{100}	.505***	.129**	.141	.227***
	(.169)	(.086)	(.107)	(.061)
PTA weight	$\frac{\lvert y_i - y_j \rvert}{y_i + y_j}$	$\frac{\lvert y_i - y_j \rvert}{y_i + y_j}$	$\frac{y_i - y_j}{y_i + y_j}$	$\frac{y_i - y_j}{y_i + y_j}$
stratification	centile	value	centile	value
	Number of obs=861,969			

Note: Sample year from 1980 to 2010. *, **, *** are 10%, 5%, 1% significance levels. Cluster (country-pairs) robust standard errors are reported in parentheses. All results are obtained by including TFEs, CTFEs, and CPFEs. y represents GDP measured in constant 2000 US dollars.

Table 4: The coefficient estimate of PTA by location dissimilarity

Estimation model	(1)	(2)	(3)
PTA_{10}	.535***	.569***	.568***
	(.037)	(.040)	(.126)
PTA_{20}	.412***	.405***	.639***
	(.049)	(.042)	(.099)
PTA_{30}	.382***	.238***	.696***
	(.111)	(.099)	(.098)
PTA_{40}	.122	-.026	.408***
	(.181)	(.085)	(.079)
PTA_{50}	-.075	-.200**	.563***
	(.086)	(.077)	(.076)
PTA_{60}	-.223**	.265*	.523***
	(.093)	(.143)	(.070)
PTA_{70}	-.083	.045	.442***
	(.093)	(.470)	(.072)
PTA_{80}	.337	.079	.412***
	(.233)	(.441)	(.071)
PTA_{90}	.401**	.410	.237***
	(.177)	(.361)	(.060)
PTA_{100}	.167	.007	-.074
	(.293)	(.624)	(.062)
PTA weight stratification	$\frac{d_{ij}}{d_{max}}$ centile	$\frac{d_{ij}}{d_{max}}$ value	$\frac{d_{ij}}{d_{max}}$ centile|PTA=1
	Number of obs=851,888		

Note: Sample year from 1980 to 2010. *, **, *** are 10%, 5%, 1% significance levels. Cluster (country-pairs) robust standard errors are reported in parentheses. Estimate result is obtained by including TFEs, CTFEs, and CPFEs. $d_{max} = 20,037km$. Outliers observations of Chile are excluded from the estimations since including Chile leads to big spike of the effect at the 9th centile. centile|PTA=1 implies that cutoff values of each centile is determined by using only the observations with PTA=1.

Table 5: The PTA effect: Absolute dissimilarity size, income and location

Model	Log-linear	Heckman 2-step
Coefficient		
PTA	.962***	1.669***
	(.071)	(.089)
$PTA \cdot ASD$	-.162**	-.196**
	(.070)	(.084)
$PTA \cdot AID$	-.271***	-.220**
	(.080)	(.094)
$PTA \cdot LD$	-2.683***	-7.121***
	(.471)	(.709)
$PTA \cdot LD^2$	2.492***	7.320***
	(.717)	(1.264)
ASD	-.192**	-.398***
	(.032)	(.063)
AID	-.195***	-.242***
	(.028)	(.055)
Marginal effect		
$TC = \Delta ln(T+1)/\Delta PTA$	.166	.144
$\partial TC/\partial ASD$	-.189	-.224
$\partial TC/\partial AID$	-.312	-.251
$\partial TC/\partial LD$	-.804	-1.447
Number of obs.	861,969	411,196
	Year: 1980-2010	

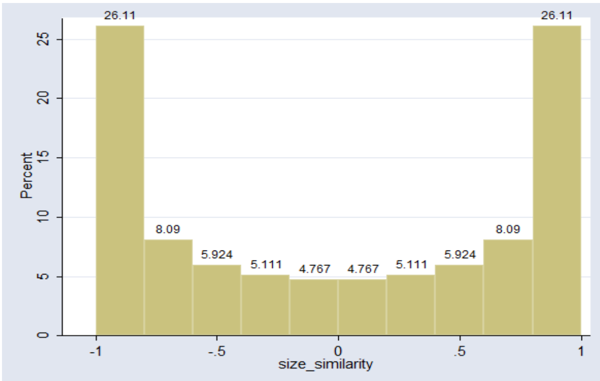
Note: *, **, *** are 10%, 5%, 1% significance levels.. Cluster (country-pairs) robust standard errors are reported in parentheses. The estimation includes AID and ASD, CPFEs and CTFEs. The marginal effects are evaluated at mean values of the variables: $ASD = .7$, $AID = .59$, and $LD = .40$.

Table 6: The PTA effect: Asymmetric dissimilarity in size, income and location

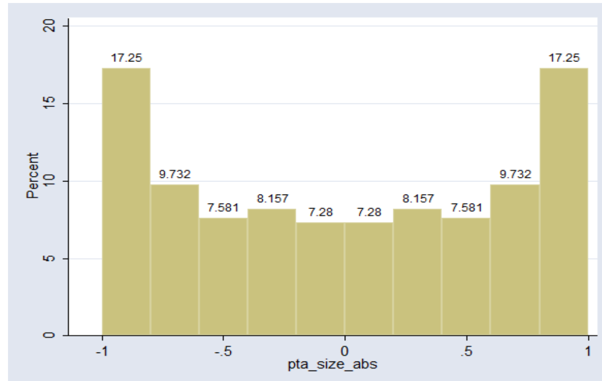
Model	Log-linear	Heckman 2-step
Coefficient		
PTA	.962***	1.564***
	(.071)	(.086)
$PTA \cdot SDP$	-.103	-.221**
	(.083)	(.101)
$PTA \cdot SDN$	-.221**	-.192**
	(.079)	(.093)
$PTA \cdot IDP$	-.338***	-.165
	(.089)	(.110)
$PTA \cdot IDN$	-.204**	-.324***
	(.098)	(.107)
$PTA \cdot LD$	-2.685***	-6.270***
	(.472)	(.544)
$PTA \cdot LD^2$	2.495***	6.373***
	(.718)	(.862)
Marginal effect		
$TC = \Delta ln(T+1)/\Delta PTA$	.170	.157
$\partial TC/\partial SDP$	-.120	-.255
$\partial TC/\partial SDN$	-.258	-.222
$\partial TC/\partial IDP$	-.395	-.191
$\partial TC/\partial IDN$	-.237	-.375
$\partial TC/\partial LD$	-.805	-1.356
	Year: 1980-2010	
Number of obs.	861,969	411,196

Note: *, **, *** are 10%, 5%, 1% significance levels. Cluster (country-pairs) robust standard errors are reported in parentheses. The estimation includes IDP, IDN, SDP, SDN, LGD, CPFEs and CTFEs. The marginal effects are evaluated at mean values of the variables. The marginal effects are evaluated at mean values of following variables: $IDP = IDN = .29$, $SDP = SDN = .35$ and $LD = .40$.

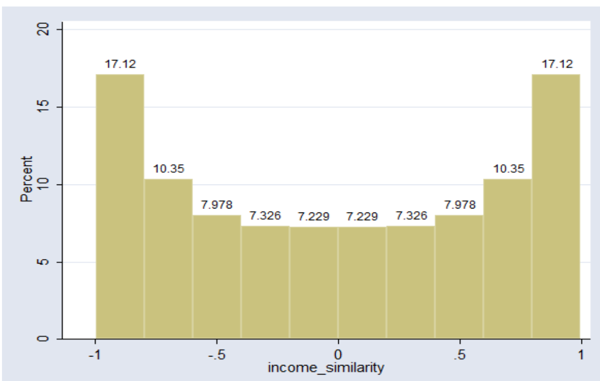
Figure 1: Distribution of country pairs by size, income and locational dissimilarity



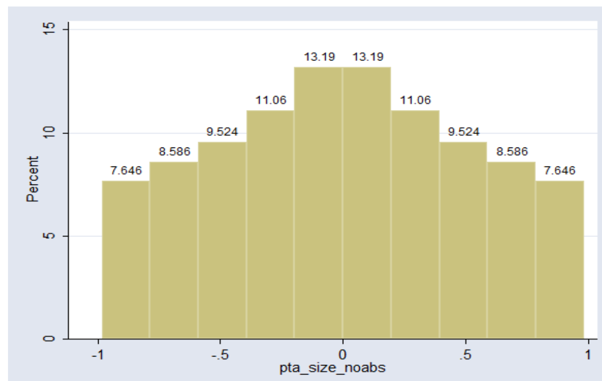
(a) All country pairs by size dissimilarity



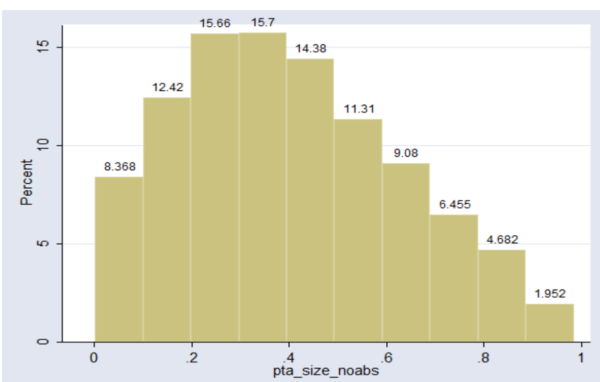
(b) Country pairs with PTAs by size dissimilarity



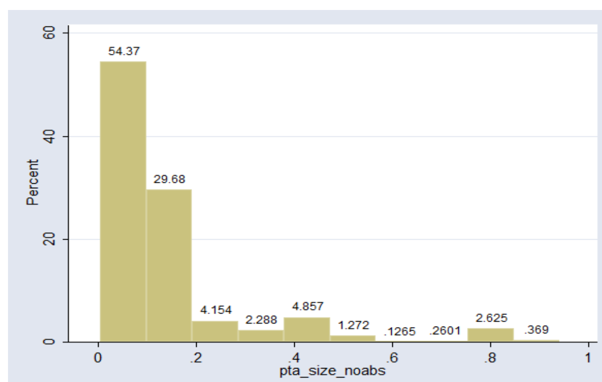
(c) All country pairs by income dissimilarity



(d) Country pairs with PTAs by income dissimilarity

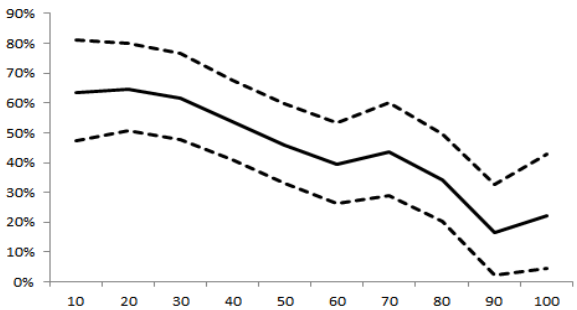


(e) All country pairs by locational dissimilarity

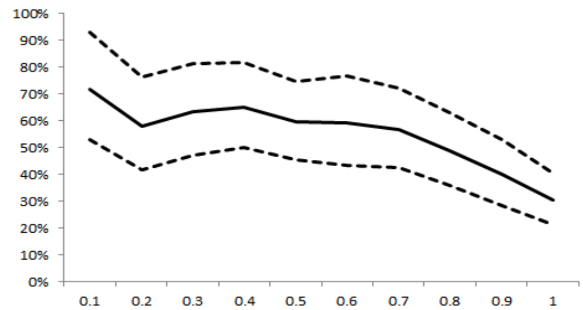


(f) Country pairs with PTAs by locational dissimilarity

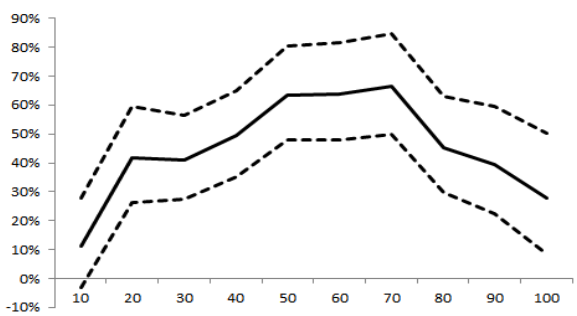
Figure 2: The trade creation effect by size dissimilarity



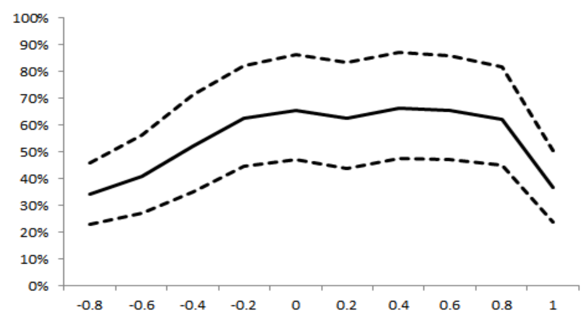
(a) $\frac{|Y_i - Y_j|}{Y_i + Y_j}$ centile



(b) $\frac{|Y_i - Y_j|}{Y_i + Y_j}$ value

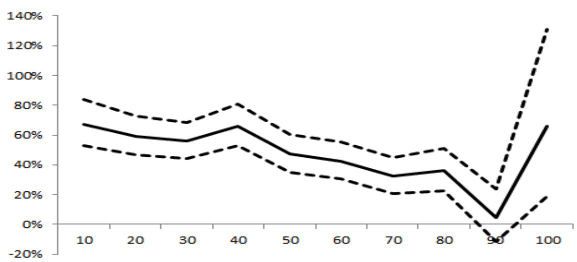


(c) $\frac{Y_i - Y_j}{Y_i + Y_j}$ centile

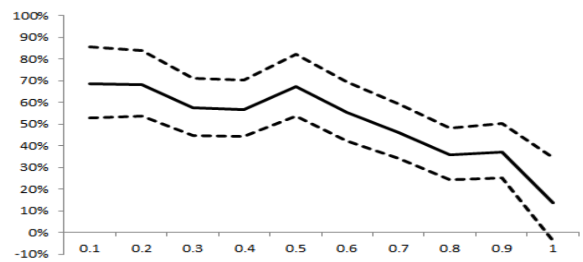


(d) $\frac{Y_i - Y_j}{Y_i + Y_j}$ value

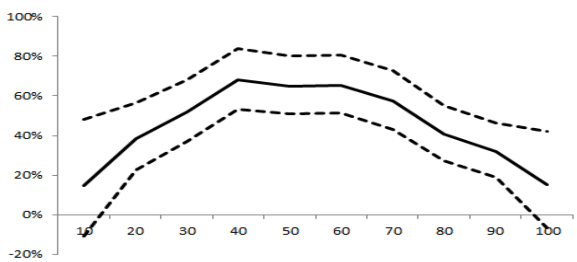
Figure 3: The trade creation effect by income dissimilarity



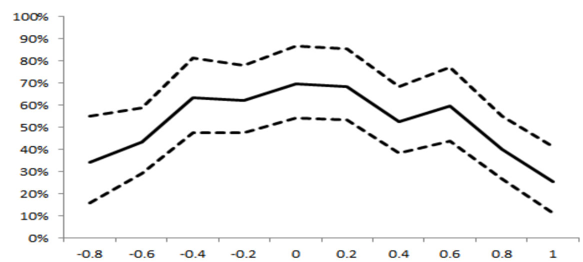
(a) $\frac{|y_i - y_j|}{y_i + y_j}$ centile



(b) $\frac{|y_i - y_j|}{y_i + y_j}$ value

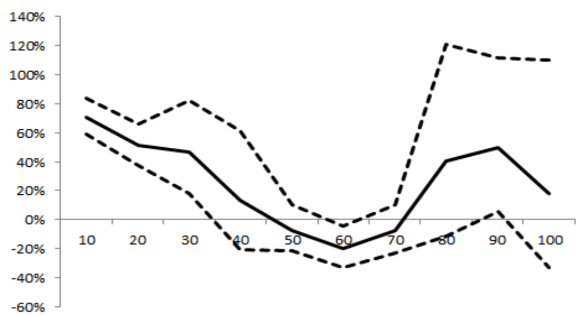


(c) $\frac{y_i - y_j}{y_i + y_j}$ centile

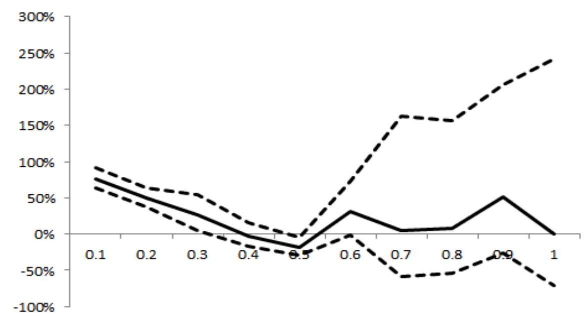


(d) $\frac{y_i - y_j}{y_i + y_j}$ value

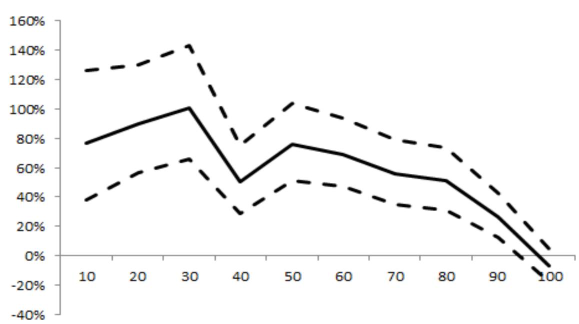
Figure 4: The trade creation effect by location dissimilarity



(a) $\frac{d_{ij}}{d_{max}}$ centile



(b) $\frac{d_{ij}}{d_{max}}$ value



(c) $\frac{d_{ij}}{d_{max}}$ centile|PTA=1

A Stratification: Generating strata indicators

In this appendix, we show how to transform the PTA_{ijt} variable into 10 PTA^p_{ijt} variables using strata indicator D^p_{ijt} in that $PTA^p_{ijt} = PTA_{ijt} \cdot D^p_{ijt}$.

First, we consider the centile stratification. We pool all the observations over i, j and t, and then use the distributions of each dissimilarity measure and its centile values as cut-off values for 10 strata to construct 10 D^p_{ijt} variables. Using SD as an example, the strata indicator is constructed as in (10):

$$D^p_{ijt} = \begin{cases} 1 & \text{if } \phi(SD_{ijt})'\text{s } (p\text{-}10)\text{th-centile} \leqq SD_{ijt} < \phi(SD_{ijt})'\text{s } p\text{th-centile} \\ 0 & otherwise \end{cases} \tag{10}$$

where $\phi(.)$ is a distribution function, and p is an indicator of strata from 1 to 10, which has a value of 10, 20, 30,...,100. The strata indicators for ASD, ID, AID and LD are constructed in the same way.

Next, we consider the value stratification. For ASD and AID with the actual values, we construct 10 strata indicators as follows using ASD as an example:

$$D^1_{ijt} = \begin{cases} 1 & \text{if } ASD_{ijt} < 0.1 \\ 0 & otherwise \end{cases} \tag{11}$$

$$\vdots$$

$$D^p_{ijt} = \begin{cases} 1 & \text{if } 0.1 \times (p\text{-}1) \leqq ASD_{ijt} < 0.1 \times p \\ 0 & otherwise \end{cases} \text{ where } p\text{=2,3,...,9} \tag{12}$$

$$\vdots$$

$$D^{10}_{ijt} = \begin{cases} 1 & \text{if } 0.9 \leqq ASD_{ijt} \\ 0 & otherwise \end{cases} \tag{13}$$

For SD and ID with the actual values, we construct 10 strata indicators as follows using SD as an example:

$$D^1_{ijt} = \begin{cases} 1 & \text{if } SD_{ijt} < -0.8 \\ 0 & otherwise, \end{cases} \tag{14}$$

$$\vdots$$

$$D^p_{ijt} = \begin{cases} 1 & \text{if } 0.2 \times (p\text{-}1) - 1 \leqq SD_{ijt} < (0.2 \times p) - 1 \\ 0 & otherwise, \end{cases} \text{ where } p\text{=2,3,...,9} \tag{15}$$

$$\vdots$$

$$D_{ijt}^{10} = \begin{cases} 1 & \text{if } 0.8 \leqq SD_{ijt} \\ 0 & otherwise, \end{cases} \tag{16}$$

For the locational dissimilarity measure with the actual values, denoting $M = max\{d_{ijt}\}$, $m = min\{d_{ijt}\}$, and $s = \frac{M-m}{10}$, we construct 10 strata indicators as follows:

$$D_{ijt}^{1} = \begin{cases} 1 & \text{if } LD_{ijt} < m + s \\ 0 & otherwise \end{cases} \tag{17}$$

$$\vdots$$

$$D_{ijt}^{p} = \begin{cases} 1 \text{ if} & m + (p-1) \times s < LD_{ijt} < m + p \times s \\ 0 & otherwise \end{cases} \quad \text{where } p\text{=2,3,...,9} \tag{18}$$

$$\vdots$$

$$D_{ijt}^{10} = \begin{cases} 1 & \text{if } LD_{ijt} \geqq m + 9s \\ 0 & otherwise. \end{cases} \tag{19}$$

Table 7: Correlation among size, income and geographical location

	SD	ID	ASD	AID	LD
SD	1				
ID	.454***	1			
ASD	0	0	1		
AID	0	0	.134***	1	
LD	0	0	.102***	.095***	1

Note: *** implies the correlation is significant at the 1% significance level.

B Correlation among size, income and geographical location

The correlations between different measures of dissimilarity are reported in Table 7. Income and size dissimilarities are highly correlated, while the point estimates for the correlation between distance and income dissimilarities, and between distance and size dissimilarities are very small. The correlation coefficients between SD and ID and between ASD and AID are .46 and .13 respectively and statistically significant at the 1% level. However, the point estimates for the correlation between LD and ASD and between LD and AID are less than .1. The remaining correlation coefficients are equal to zero by construction where one variable distributes over both positive and negative values (i.e. SD and ID) while the other one distributes over only positive values (i.e. ASD, AID and LD).

C Heterogeneity of PTAs: the stratification approach

In this appendix, we replicate Tables 2, 3 and 5 but include the variable that captures the trade diversion effect of PTAs, namely $OPTA_{ijt} = \sum_{k \neq j} PTA_{ikt}$ as an additional regressor, and using biennial CTFEs to circumvent the multicollinearity problem as in Cheong et al. (2012). The estimation equation is as follows:

$$ln(T_{ijt}+1) \quad = \quad \mathbf{X}_{ijt}\alpha + \sum_{p=1}^{10}(\beta^p PTA^p_{ijt} + \gamma^p D^p_{ijt}) + \delta \cdot OPTA_{ijt} + \omega_{ij} + u_{it} + v_{jt} + \epsilon_{ijt} \quad (20)$$

where u_{it} and v_{jt} are allowed to vary every two years, i.e. $u_{it} = u_{i,t+1}$ and $v_{jt} = v_{j,t+1}$ for $t = 1,3,5....$

Table 8 reports the results. Columns (1), (2), (3), and (4) correspond, respectively, to columns (1), (2), (3), and (4) in Table 2; columns (5), (6), (7), and (8) correspond, respectively, to columns (1), (2), (3), and (4) in Table 3; and columns (9) and (10) correspond, respectively, to columns (1) and (2) in Table 4. The estimation coefficients are very similar to those from Section 4.

Table 8: Nonparametric estimates of Heterogenous PTA effects on trade creation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PTA_{10}	.532	.583	.228	.380	.565	.573	.210	.364	.568	.607
	(.053)	(.060)	(.077)	(.045)	(.049)	(.052)	(.134)	(.076)	(.037)	(.041)
PTA_{20}	.542	.499	.430	.405	.517	.570	.398	.430	.470	.439
	(.046)	(.057)	(.061)	(.054)	(.043)	(.047)	(.064)	(.054)	(.051)	(.043)
PTA_{30}	.520	.537	.408	.476	.489	.502	.488	.562	.319	.275
	(.046)	(.054)	(.053)	(.062)	(.041)	(.045)	(.053)	(.053)	(.107)	(.099)
PTA_{40}	.467	.544	.458	.538	.553	.495	.586	.547	.264	.046
	(.045)	(.050)	(.052)	(.060)	(.044)	(.043)	(.048)	(.049)	(.183)	(.087)
PTA_{50}	.409	.509	.542	.552	.428	.562	.562	.587	.058	-.180
	(.047)	(.048)	(.051)	(.061)	(.044)	(.044)	(.047)	(.050)	(.090)	(.078)
PTA_{60}	.360	.506	.531	.523	.393	.485	.552	.570	-.240	.260
	(.050)	(.054)	(.053)	(.063)	(.045)	(.045)	(.046)	(.050)	(.093)	(.112)
PTA_{70}	.393	.488	.536	.544	.321	.420	.483	.456	-.034	.799
	(.056)	(.049)	(.055)	(.061)	(.047)	(.044)	(.049)	(.052)	(.092)	(.166)
PTA_{80}	.313	.432	.376	.533	.350	.347	.357	.493	.297	.053
	(.056)	(.047)	(.060)	(.061)	(.054)	(.045)	(.051)	(.054)	(.138)	(.581)
PTA_{90}	.195	.367	.312	.499	.094	.355	.288	.349	.987	.394
	(.071)	(.046)	(.069)	(.059)	(.087)	(.048)	(.054)	(.052)	(.176)	(.371)
PTA_{100}	.289	.304	.253	.298	.587	.169	.177	.234	.157	-.323
	(.083)	(.040)	(.088)	(.051)	(.169)	(.087)	(.106)	(.062)	(.304)	(.407)
$OPTA$	-.013	-.013	-.013	-.013	-.013	-.013	-.013	-.013	-.013	-.013
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
Year: 1980-2010, Number of observations=861,969										
weight type	abs	abs	non-abs	non-abs	abs	abs	non-abs	non-abs	non-abs	non-abs
PTA weight	size	size	size	size	income	income	income	income	distance	distance
stratification	centile	value	centile	value	centile	value	centile	value	centile	value

Note:Cluster (contry-pairs) robust standard errors are reported in parentheses. All estimations include WTO pair membership dummy, stratification dummy variables, biennial CTFEs, and CPFEs as additional control variables. PTA weight measure used in this table is the same as the weights in the main section.

D The stratification method with Heckman (1979) procedure

In this appendix, we explain how to extend the log-linear gravity model to a generalized gravity model that accounts for self-selection by the Heckman (1979) procedure.

We obtain Heckman's(1979) correction term for self-selection of trade by estimating the following probit model:

$$\begin{aligned} Pr(T^*_{ijt} = 1|\mathbf{M}_{ijt}) &= \alpha_0 + \alpha_1 lnY_{it} + \alpha_2 lnY_{jt} + \beta_1 \mathbf{X}_{ijt} + \beta_2 \mathbf{Z}_{ijt} \\ &\quad + \gamma_1 PTA_{ijt} + \mu_t + \epsilon_{ijt} \end{aligned} \tag{21}$$

where the dependent latent variable T^*_{ijt} is equal to zero if $T_{ijt} = 0$ and one if $T_{ijt} > 0$, and $\mathbf{M}_{ijt}$ is a vector of all observed variables and excluded variables in the bilateral trade flows equation.

The exclusion restrictions require variables in $\mathbf{Z}_{ijt}$ to be statistically significant in determining whether two countries trade with each other, but not statistically significant in determining their trade flows if they do trade. Based upon availability of data, our potential exclusion restriction variables include religion as in Helpman et al. (2008)[22], costs in relation to infrastructure (Magee and Massoud, 2011)[23], and annual event count of riots and violent demonstrations (Magee and Massoud, 2011)[24]. The religion data are available for only two time points (1970 and 2000), thus we extrapolate them for other unavailable years.[25] 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 construct the variable by multiplying a country-pairs' waterways for available time points and extrapolate it for the other time points.[26] It is found that both religion and costs in relation to infrastructure by waterways satisfy the exclusion restrictions.

In the second stage, the trade flows equation to be estimated is given by:

$$\begin{aligned} ln(T_{ijt}) &= \alpha \mathbf{X}_{ijt} + \sum_{p=1}^{10} (\beta^p PTA^p_{ijt} + \gamma^p D^p_{ijt}) + \delta \cdot IM\hat{R}_{ijt} \\ &\quad + \omega_{ij} + u_{it} + v_{jt} + \epsilon_{ijt} \end{aligned} \tag{22}$$

where $T_{ijt} > 0$ and IMR is the inverse mills ratio (IMR) obtained from (21). Thus, in equation (22), bias due to self-selection of positive trade is controlled by $IM\hat{R}_{ijt}$ Table 9 reports the results of two-stage estimations where the extrapolated religion variable is used as the excluded variable with stratification by the centile.[27] We obtain the same qualitative results as in the

[22]The way to construct the variable "religion" is explained in the appendix in Helpman et al. (2008).

[23]We use the following four variables: (i) kilometer (km) of waterways square km of land area, (ii) km of railways square km of land area, (iii) km of highways square km of land area, and (iv) airports square km, to calculate proxy variables for fixed trade cost. For each variable, we average the values of the importing-country and the exporting-country. The data are available at http://www.facstaff.bucknell.edu/cmagee/.

[24]We think this can be a potential excluded variable because if a country is politically or socially unstable, it is too costly or risky for traders to enter the market, but once they enter, the trade volume would be determined by economic factors instead.

[25]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.

[26]We use the 1992 data for years before 1992 and 2004 data for 2004 onward.

[27]Since religion is only available for two periods, we provide the results from waterways.

log-linear model and confirm the heterogeneous effects of PTAs.

Table 9: Heterogenous PTA effects on trade creation: Heckman Procedure

	(1)	(2)	(3)	(4)	(5)
PTA_{10}	.714	.083	.725	.078	.716
	(.060)	(.090)	(.060)	(.150)	(.048)
PTA_{20}	.768	.452	.713	.528	.563
	(.054)	(.068)	(.052)	(.076)	(.051)
PTA_{30}	.719	.618	.688	.615	.348
	(.055)	(.062)	(.050)	(.061)	(.076)
PTA_{40}	.666	.683	.746	.780	.267
	(.058)	(.064)	(.052)	(.058)	(.148)
PTA_{50}	.577	.740	.613	.743	-.348
	(.054)	(.059)	(.051)	(.056)	(.183)
PTA_{60}	.563	.751	.501	.729	-.291
	(.058)	(.060)	(.052)	(.056)	(.095)
PTA_{70}	.450	.707	.401	.685	-.346
	(.066)	(.061)	(.055)	(.060)	(.091)
PTA_{80}	.376	.499	.456	.513	.181
	(.068)	(.066)	(.066)	(.060)	(.113)
PTA_{90}	.194	.371	.124	.340	.522
	(.091)	(.078)	(.107)	(.064)	(.144)
PTA_{100}	-.173	.120	.346	.248	-.521
	(.119)	(.118)	(.322)	(.153)	(.267)
	Year: 1980-2010, Number of observations=466,716				
weight type	abs	non-abs	abs	non-abs	non-abs
PTA weight	size	size	income	income	distance

Note: Cluster (country-pairs) robust standard errors are reported in parentheses. All estimations include WTO pair membership dummy, stratification dummy variables, country-time, and country-pair fixed effects as additional control variables. PTA weight measure used in this table is the same as the weights in the main section. In all estimations, we use centile values in the stratification.

E Non-absolute symmetric measures of dissimilarity

When the non-absolute but symmetric measures of size and income dissimilarity are used, (5) is modified into

$$\begin{aligned} ln(T_{ijt}+1) = {} & \mathbf{X}_{ijt}\alpha + \beta_1 PTA_{ijt} + \beta_2 PTA_{ijt}\cdot SD_{ijt} + \beta_3 PTA_{ijt}\cdot SD^2_{ijt} \\ & + \beta_4 PTA_{ijt}\cdot ID_{ijt} + \beta_5 PTA_{ijt}\cdot ID^2_{ijt} + \beta_6 PTA_{ijt}\cdot LD_{ij} \\ & + \beta_7 PTA_{ijt}\cdot LD^2_{ij} + \beta_8 SD_{ijt} + \beta_9 SD^2_{ijt} + \beta_{10} ID_{ijt} + \beta_{11} ID^2_{ijt} \\ & + \delta\cdot I\hat{MR}_{ijt} + \omega_{ij} + u_{it} + v_{jt} + \epsilon_{ijt} \end{aligned} \tag{23}$$

Our results from section 4 suggest that $\beta_2 = 0$, $\beta_3 < 0$, $\beta_4 = 0$, $\beta_5 < 0$, and $\beta_6 < 0$. In particular, $\beta_2 = \beta_4 = 0$ if the effect of PTAs is an inverse U-shaped function of SD and ID, centering at their zero values.

The estimation results of (23) are shown in Table 10. The coefficients of $PTA\cdot SD$ and $PTA\cdot ID$ are small and statistically insignificant while $PTA\cdot SD^2$ and $PTA\cdot ID^2$ are relatively large and statistically significant at the 5% and 1% level, respectively. This implies that the maximal effect of a PTA on trade flows takes place when country-pairs are identical in size and income, other things equal. The coefficients of $PTA\cdot LD$ and $PTA\cdot LD^2$ are statistically significant at the 1% level and the magnitudes are similar to the one in Table 10.

The marginal effects are evaluated at the mean values of $SD > 0\,(.7)$, $SD^2\,(.58)$, $ID > 0\,(.59)$, $ID^2\,(.44)$ $LD\,(.40)$, and $LD^2\,(.22)$. The mean values of SD and ID are not used here because they are equal to zero by definition. Instead, we use the mean values of SD conditional on $SD > 0$ and of ID conditional on $ID > 0$. At these mean values, a PTA is expected to increase intra-bloc trade by 16%, and the effect is moderated by .17, .46, and .79 percentage points, respectively, if size, income, and location dissimilarity increase by .01. Except for that of income dissimilarity, the marginal effects are quite comparable to when absolute dissimilarity measures are used.

Heckman (1979) procedure confirms the robustness of the qualitative results from the log-linear model. The estimates of the two interaction terms with LD, once again, are noticeably larger in the Heckman estimation.

Table 10: The PTA effect: Non-absolute dissimilarity in size, income and location

Model	Log-linear	Heckman 2-step
Coefficient		
PTA	.874***	1.489***
	(.061)	(.073)
$PTA \cdot SD$	.059	-.018
	(.040)	(.050)
$PTA \cdot SD^2$	-.149**	-.214***
	(.064)	(.076)
$PTA \cdot ID$	-.067	.079
	(.049)	(.058)
$PTA \cdot ID^2$	-.279***	-.282***
	(.084)	(.095)
$PTA \cdot LD$	-2.592***	-6.136***
	(.474)	(.542)
$PTA \cdot LD^2$	2.392***	6.181***
	(.722)	(.857)
Marginal effect		
$TC = \Delta ln(T+1)/\Delta PTA$	.158	.168
$\partial TC/\partial SD$	-.173	-.371
$\partial TC/\partial ID$	-.459	-.296
$\partial TC/\partial LD$	-.785	-1.391
Number of obs.	861,969	411,196
	Year: 1980-2010	

Note: *, **, *** are 10%, 5%, 1% significance levels. Cluster (country-pairs) robust standard errors are reported in parentheses. The estimation includes ID, ID^2, SD, SD^2, LGD, LGD^2, CPFEs and CTFEs. The marginal effects are evaluated at mean values of following variables: $SD = .7$, $SD^2 = .58$, $ID = .59$, $ID^2 = .44$, and $LD = .40$.