# CCES Discussion Paper Series
## Center for Research on Contemporary Economic Systems

**Graduate School of Economics**
**Hitotsubashi University**

CCES Discussion Paper Series, No.51
September 2013

# On the Trade and Price Effects of Preferential Trade Agreements

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## Abstract

In this paper we extend recent work using the Gravity Model to estimate the trade and price effects of Preferential Trading Arrangements (PTAs), by explicitly taking into account the extent of the *preferential* access being provided by the importer. This involves specifying a trade model, deriving appropriate PTA variables, appending them to a gravity-type equation and estimating it. We find that relying on the estimated coefficient on a PTA dummy variable overestimates the trade creating effects of PTAs. We also use average tariff and estimated trade cost data to calculate the effects of the PTAs in force in 2006 on trade flows. We show that ignoring the general equilibrium effects of PTA membership greatly distorts the distribution of outcomes.

JEL Classification Numbers: F13, F14

Key Words: Preferential Trading Arrangements, Gravity Model, Trade Diversion

We thank Richard Baldwin, Peter Egger, Alan Woodland and participants at the 2011 ETSG Meetings in Copenhagen; the Hitotsubashi-UNSW Conference on International Trade and FDI, Sydney 2011; the Australasian Trade Workshop at UNSW 2012; a seminar at KOF ETH Zurich and workshops at GEP-Nottingham and Hitotsubashi University for comments.

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## 1. Introduction

With the apparent dormancy of the Doha Round, Preferential Trade Agreements (PTAs) now appear to many policy makers to be the major practical route for obtaining increased market access for their nation's exports. Many countries are now involved in multiple agreements,[1] expanding the geographical scope of the predominantly regional trading arrangements of the past. The economic analysis of discriminatory trade of this type has always been a challenge, and discussions of the trade effects of PTAs are still often cast in terms of Viner's concepts of trade creation and trade diversion. Trade creation emerges because partners can now compete with domestic producers free of trade barriers. Trade diversion occurs because partners now have preferential access to the domestic market relative to third parties. Both effects generate increased trade between partners: the former at the expense of domestic producers; the latter at the expense of trade with non-members. But trade between members are not the only trade flows affected by a PTA.

Estimating the magnitude of the trade effects of PTAs has typically relied on the gravity equation, with total bilateral trade or total exports as the variable of interest. In the absence of a theory-based alternative, the significance and magnitude of the estimated coefficients on dummies indicating the presence (or absence) of a PTA between two countries have provided the evidence. Here we assess this pragmatic approach, taking as our starting point the observation that what usually motivates the formation of a PTA is the prospect of *preferential* access for exports.[2] Yet the extent to which the access thus obtained is truly preferential cannot be captured by a dummy variable since it will depend on whether competitors also have preferential access to the same market through this or other PTAs. If preferences are available to all exporters, then none have preferential access. In the past when countries were typically members of one PTA at most, this was perhaps a secondary issue. But now with most countries members of multiple agreements[3],

[1] The number of PTAs reported to the GATT/WTO was 25 in 1990, 91 in 2000, 194 in 2007 and more than 230 in 2010 (Urata and Okabe, 2007; Fugazza and Nicita, 2013).

[2] Baldwin and Jaimovich (2012) emphasise that each grant of preferential access increases the incentive for other countries to form and join PTAs.

[3] Our dataset consists of 174 countries. Of these 150 were at some point in more than one PTA. EU countries tend to be in the most PTAs. In addition to their own PTA, they have agreements with other regional blocs such as the European Economic Area, European Free Trade Association, the Overseas Countries and Territories, and the CARIFORUM, as well as a number of bilateral agreements with countries such as Chile, Cote d'Ivoire, Croatia, Egypt, Faroe Islands, Israel, Jordan, Lebanon, Macedonia, Mexico, Montenegro, Morocco, South Africa, Syria, Turkey, Tunisia, and the Palestinian Authority.

the *extent* of preferential access is likely to be important for the trade effects of PTA membership. We derive a variable that captures the effects of preferential access below.[4]

The empirical literature using the gravity equation to analyse the trade creation effects of PTAs goes back to the 1970s. This work has taken on greater coherence as more attention has been paid to the theory underlying the gravity equation and the econometrics of its estimation. Several issues have arisen.[5] First, the importance of including controls for what Anderson and van Wincoop (2003) refer to as 'multilateral resistances' (MR). Because the average trade costs of a country will affect its bilateral trade, failure to control for these induces omitted variables bias. Second, the recognition that PTA membership is endogenous. Allowance should be made for unobserved bilateral heterogeneity that influences trade and extends beyond the factors explicitly included in the empirical analysis. Countries that trade more for these unobserved reasons may be more likely to join a PTA, and the omission of these factors will bias the PTA estimate upwards.[6] Third, the PTA coefficient estimate itself is subject to omitted variable bias if a single PTA dummy is included but the impacts of preferences on bilateral trade flows vary across individual PTAs. Finally, as noted earlier, by focussing only on a dummy variable based on joint PTA membership, the analysis ignores the general equilibrium effects that PTAs have on all trading countries (Egger et al, 2011). The major objective of this paper is to use a familiar model to derive variables capturing these general equilibrium effects and to illustrate the impact of excluding them from the analysis.[7]

To date a huge literature has accumulated, producing what appears to be a mixed bag of results on how much PTAs actually increase trade among members. A recent meta-analysis of cross-section and panel gravity equations that include a PTA dummy variable considers 85 studies and

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[4] See Fugazza and Nicita (2013) for a detailed discussion and analysis of preferential access. They use disaggregated data to construct two aggregate indices of preferences - *direct* (i.e. the preferences given to import-competing firms) and *relative* (i.e. the preferences relative to other exporters). Both are calculated at the bilateral level.

[5] See Baldwin and Taglioni (2006) for a discussion of common errors in gravity estimation and illustrations of the biases they cause.

[6] This is a point emphasised by Baier and Bergstrand (2002, 2004). They find that two countries are more likely to have a PTA the larger and more similar their GDPs, the closer they are to each other but the more remote the pair are from the rest of the world, and the wider (narrower) the difference in their relative factor endowments with respect to each other (rest of world). Baier and Berstrand (2007) suggest using bilateral fixed effects in a panel data setting to control for this, the inclusion of which also controls for the time-invariant component of unobservable MR.

[7] A further issue is the desirability of including *both* the intensive margin (changes to the volume of existing trade flows) and the extensive margin (opening of new trade flows or complete closing of existing trade flows) in the empirical analysis. We leave this for later work, however, since our focus here is on how the introduction of a fuller set of PTA variables affects the estimated outcomes, rather than deriving the best set of estimates. Egger et al (2011) rank the relative magnitudes of the biases introduced by these various omissions. This ranking is, in descending order: the omission of the general equilibrium effects; treating PTA membership as exogenous; disregarding the zero trade flows (though they do not find that PTA membership has a statistically significant impact on the extensive margin); disregarding heterogeneous firms; and ignoring heterogeneous tariffs (though the last two biases are quite small).

1827 point estimates. The mean (median) PTA effect is an 80% (46%) increase in bilateral trade. After filtering out the 'publication selection' and other biases in these estimates, the authors conclude that there is a robust, positive PTA effect equivalent to an increase in trade of around 40% (Cipollina and Salvatici, 2010).[8] Our interest is in how this conclusion is likely to be affected once we explicitly measure preferential access and allow for the general equilibrium price effects of PTAs.

In summary then, the contribution of this paper is as follows. In Section 2 we use a familiar model to derive and identify the effects of PTA formation. This produces a set of PTA variables, which take account of PTA membership, the degree of preferential access into the importing country's market and the relative price effects of the PTAs currently in force. In section 3 we then use this model along with readily available estimates of average tariffs and trade costs to calculate the effects of PTA membership on bilateral trade flows for 174 countries in 2006. We show that ignoring the relative price effects leads to misestimates of the average effects of PTA membership, and neglects important aspects of the distributions of these outcomes. In Section 4 we step away from the constraints of the model, and add our (model-based) PTA variables to a gravity equation explaining bilateral trade flows. This allows us to compare the estimated average effects of PTA membership from simply including a standard PTA dummy, with those from including our full set of PTA variables. We find that the PTA dummy overestimates the average effects of PTA membership by about twenty percentage points. Section 5 concludes.

## 2. Preferential Access

To illustrate the potential importance of preferential access in explaining trade flows in a gravity equation context, we adapt the familiar general equilibrium endowment model of Anderson and van Wincoop (2003). Consider a world of $n+1$ countries where each country is specialised in the production of its own good and has a fixed real output. Countries have identical, homothetic CES preferences. Consumers in county $j$ maximise:

$$\left[\sum_{i=0}^{n} \beta_i^{\sigma/[\sigma-1]} c_{ij}^{[\sigma-1]/\sigma}\right]^{\sigma/[\sigma-1]} \qquad \text{s.t.} \sum_i p_{ij} c_{ij} = p_j\, \bar{y}_j \tag{1}$$

Where $\sigma$ is the elasticity of substitution between goods, $\beta_i$ is a positive demand parameter relating to product $i$, $\bar{y}_j$ is the real output of country $j$, $p_j$ is the relative price of the output of country $j$ (the output of country 0 is chosen as the numeraire), $c_{ij}$ is the consumption of and $p_{ij}$

[8] The authors also conclude that estimates are lower if (i) average bilateral trade flows (rather than just exports or imports) are used; (ii) if the PTA dummy is simply included as a control variable; and (iii) if coefficients are estimated for individual PTAs.

is the price of country $i$'s output in country $j$. Trade costs imply that prices differ between countries. Let $t_{ij} \geq 1$ be the trade cost factor between country $i$ and $j$, implying that $p_{ij} = p_i t_{ij}$. From (1), the value of the demand for country $i$'s goods in country $j$ can be derived as:

$$X_{ij} = \frac{[\beta_i p_i t_{ij}]^{1-\sigma}}{R_j} p_j \bar{y}_j \quad (2)$$

where $R_j = \sum_{k=0}^{n} [\beta_k p_k t_{kj}]^{1-\sigma}$ is a measure of aggregate consumer prices in country $j$. In order to convert (2) into a gravity equation, Anderson and van Wincoop then use the market clearing conditions to solve for $[\beta_i p_i]^{1-\sigma}$. The market clearing condition for the output of country $i$ requires that the value of its output equals the value of demand for it – i.e. from (2) that:

$$p_i \bar{y}_i = \sum_{k=0}^{n} X_{ik} = [\beta_i p_i]^{1-\sigma} \sum_{k=0}^{n} t_{ik}^{1-\sigma} \frac{p_k}{R_k} \bar{y}_k \quad (3)$$

When the solution for $[\beta_i p_i]^{1-\sigma}$ is substituted in (2) we obtain a gravity equation:

$$X_{ij} = \frac{Y_i Y_j}{Y_W} \frac{t_{ij}^{1-\sigma}}{\Pi_i P_j} \quad (4)$$

where $Y_i$ and $Y_W$ are the values of income (and expenditure) in country $i$ and the world respectively, $\Pi_i \equiv \sum_{k=0}^{n} t_{ik}^{1-\sigma} \frac{\theta_k}{P_k}$ and $P_j \equiv \sum_{k=0}^{n} t_{kj}^{1-\sigma} \frac{\theta_k}{\Pi_k}$ are the 'multilateral resistance' (MR) terms, and $\theta_k$ is the share of country $k$ in world income. Bilateral trade costs therefore appear directly in the gravity equation but also indirectly through the MR terms. Thus a change in bilateral trade costs resulting from a PTA between $i$ and $j$, will change $\Pi_i$ and $P_j$ and thereby affect *all* bilateral trade flows involving either $i$ or $j$. When estimating this equation, the standard practice is to sweep the MR terms into (time varying if appropriate) country fixed effects, and to focus only on the direct trade costs effect (i.e. the $t_{ij}^{1-\sigma}$ term), which is proxied with the usual variables – geographical distance and dummies for common languages and borders, being landlocked, former colonial status, etc. Also included are dummy variables for PTA status, if preferential trade is of interest. The coefficients on the PTA dummies are then interpreted as indicating the net trade creating effects of the relevant PTA, though it is recognised that the presence of PTAs will also affect bilateral trade flows through the trade costs and induced product price changes in the MR terms.[9]

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[9] Anderson and Yotov (2011) explicitly use these relationships to measure the terms of trade and global efficiency effects of PTAs, using data on 2 digit manufacturing sectors.

Our objective in this section is to examine the implications of PTA membership on trade flows in a little more detail, with the aim of extracting variables that better capture these effects for the empirical analysis. We begin by deriving the effects of an arbitrary set of changes in trade costs on bilateral export flows.[10] Let $\hat{z}$ denote a proportional change $(dz/z)$ for any variable z. Then using (2) and allowing for the induced relative price changes but assuming no changes in real outputs, we have:

$$\hat{X}_{ij} = -[\sigma - 1]\left[\hat{p}_i + \hat{t}_{ij}\right] + \hat{p}_j - \hat{R}_j \quad \text{and} \quad \hat{R}_j = -[\sigma - 1]\sum_{k=0}^{n} m_{kj}\left[\hat{p}_k + \hat{t}_{kj}\right] \tag{5}$$

This allows us to write:

$$\hat{X}_{ij} = -[\sigma - 1]\left\{\left[\hat{p}_i + \hat{t}_{ij}\right] - \sum_{k=0}^{n} m_{kj}\left[\hat{p}_k + \hat{t}_{kj}\right]\right\} + \hat{p}_j \tag{5A}$$

where $m_{ij} \equiv \frac{X_{ij}}{p_j \bar{y}_j}$ denotes the (import) market share of country $i$ in $j$, with $m_{ij} \geq 0$ and $\sum_{i=0}^{n} m_{ij} = 1$, where the latter includes home sales of $j$. The term in brackets on the right of (5A) indicates that the value of exports from $i$ to $j$ falls if the cost of $i$'s product rises in the $j$ market, relative to a market-share weighted average of cost changes for all suppliers, including $j$ itself. The final term indicates that an increase in the relative price of $j$'s output tends to increase the value of imports from $i$ by increasing numeraire income in $j$. As (5A) reveals, changes in trade costs will affect trade flows through three channels – a *preferential access effect*, a *relative price effect* and an *expenditure effect* – as laid out in equation (5B).

$$\hat{X}_{ij} = \underbrace{-[\sigma - 1]\left[\hat{t}_{ij} - \sum_{k=0}^{n} m_{kj}\,\hat{t}_{kj}\right]}_{preferential\ access\ effect} \underbrace{-[\sigma - 1]\left[\hat{p}_i - \sum_{k=1}^{n} m_{kj}\,\hat{p}_k\right]}_{relative\ price\ effect} \underbrace{+\hat{p}_j}_{\substack{expenditure \\ effect}} \tag{5B}$$

The preferential access effect depends on $T_{ij} \equiv \left[\hat{t}_{ij} - \sum_{k=0}^{n} m_{kj}\,\hat{t}_{kj}\right]$, which is the relative trade cost change – i.e. the proportional change in the trade cost on this specific trade flow, relative to the market share-weighted proportional changes in trade costs of all sales in this importer's market. The other two effects depend on the induced changes in relative prices, and as we shall see, these changes are functions of all the preferential access effects. To determine the relative price changes we totally differentiate the market clearing conditions (3) which gives us:

[10] Effectively we take a linear approximation to the *changes* in the trade costs induced by PTA formation. Baier and Bergstrand (2009) adopt a similar approach to estimating the *level* of trade costs by taking a first-order log-linear Taylor-series expansion of the MR terms. Their main objective is to demonstrate that this approximation, which considerably simplifies the estimation, generates equivalent estimates to those from the computationally more demanding non-linear least squares method of Anderson and van Wincoop (2003). One illustration of this equivalence is the changes in trade flows from removing the preferences in the European Economic Area.

$$\hat{p}_i = [1-\sigma]\hat{p}_i + \sum_{k=0}^{n} e_{ik}\left[[1-\sigma]\hat{t}_{ik} + \hat{p}_k - \hat{R}_k\right] \quad (6)$$

where $e_{ij} \equiv \frac{X_{ij}}{p_i\bar{y}_i}$ denotes the (export) share of country $j$ in the output of country $i$, with $e_{ij} \geq 0$ and $\sum_j e_{ij} = 1$, where the latter includes home sales of $i$. Note further that $e_{ij} = \frac{X_{ij}}{p_j\bar{y}_j}\frac{p_j\bar{y}_j}{p_i\bar{y}_i} = m_{ij}\frac{\theta_j}{\theta_i}$. Using (5) to substitute for $\hat{R}_k$ and rearranging leads to:

$$\sigma\hat{p}_i - \sum_{k=0}^{n} e_{ik}\left[\hat{p}_k + [\sigma-1]\sum_{j=1}^{n} m_{jk}\hat{p}_j\right] = -[\sigma-1]\sum_{k=0}^{n} e_{ik}\, T_{ik} \quad (7)$$

The right side of this equation depends on $\bar{T}_i \equiv \sum_{k=0}^{n} e_{ik}\, T_{ik}$, which is the sales share weighted average of all the relative trade cost changes for exporter $i$. If this is positive (negative), then $i$'s export trade costs rise (fall) relative to its competitors on average, and world demand for $i$'s product falls (rises). We can write (7) as:

$$\sigma\hat{p}_i - \sum_{k=0}^{n} e_{ik}\left[\hat{p}_k + [\sigma-1]\sum_{j=1}^{n} m_{jk}\hat{p}_j\right] = -[\sigma-1]\bar{T}_i \quad (8)$$

Taking these equations for all the non-numeraire goods, gives us a system of $n$ equations to solve for the $n$ relative output price changes. This system can be written as:

$$[D(\sigma) - S]\hat{p} = -D(\sigma-1)\bar{T} \quad (9)$$

Where $\hat{p}$ is the $n \times 1$ vector of proportional changes in relative output prices; $D(\sigma)$ is an $n \times n$ diagonal matrix with $\sigma$ as its diagonal elements; S is a $n \times n$ matrix whose $ij$th term is $e_{ij} + [\sigma-1]\sum_{k=0}^{n} e_{ik}m_{jk} > 0$; and $\bar{T}$ is the $n \times 1$ vector of export-market-share-weighted relative trade cost changes defined above. Since the off-diagonal elements of $[D(\sigma) - S]$ are all negative and the sum of the coefficients in the $i$th row is $e_{i0} + [\sigma-1]\sum_{k=0}^{n} e_{ik}m_{0j} > 0$ ; then the diagonal elements are all positive and $[D(\sigma) - S]$ has a dominant diagonal. Thus $[D(\sigma) - S]$ is non-singular. In principle we can then solve for the induced changes in relative prices as functions of the changes in trade costs from:

$$\hat{p} = -D(\sigma-1)[D(\sigma) - S]^{-1}\bar{T} \quad (10)$$

and these solutions can be substituted in (5A) to obtain the total effects of trade costs changes on bilateral trade flows.

Our interest is in identifying the effects of PTA membership amongst the trading parties on the value of their bilateral exports. We start from a pre-PTA equilibrium (i.e. where there are no PTAs), and then suppose countries form PTAs with an exogenously chosen subset of their trading partners. If we knew the trade cost reductions associated with PTA membership, we could insert these in (5B) and (10), solve for the induced price changes from (10), add these to (5B) and report the corresponding changes in bilateral trade flows. Indeed we report the results of two such exercises in Section 3 below, using average MFN tariffs as the estimated trade cost reductions to illustrate the workings of the model and to provide some baseline estimates. But in practice tariffs are but one element of trade costs, and we apply a more flexible approach for the gravity analysis in Section 4.

In our gravity analysis we assume PTA membership has a uniform effect on bilateral trade costs and suppose that if country $k$ grants preferential access to exports from a set of trading partners $i \in S_k$, this corresponds to an equi-proportionate reduction in the trade costs for the corresponding export flow – i.e. these costs become $(1-\gamma)t_{ik}; 0<\gamma<1, i \epsilon S_k$, implying that $\hat{t}_{ik}=-\gamma$. We can then interpret $\overline{m}_k \equiv \sum_{i \in S_k} m_{ik}$, which is the pre-PTA market share of its PTA partners in country $k$, as a measure of the extent of *preferential access offered by* $k$; and $\bar{e}_k \equiv \sum_{j \in S_k} e_{kj}$, which is the pre-PTA share of its PTA partners in country $k$'s exports, as the extent of *preferential access offered to* $k$. Let $I_{ij}$ be a standard PTA dummy variable – i.e. $I_{ij}=1$ if countries $i$ and $j$ are in the same PTA and 0 otherwise. Then $T_{ij}=[I_{ij}-\overline{m}_j]\gamma$ and $n_i \equiv \sum_{k=0}^{n} e_{ik}[I_{ik}-\overline{m}_k]$ is a measure of the *net preferential access received by* $i$. This is an export-share weighted average of the preferential access that $i$ receives in each export market. Equation (8) then becomes:

$$\sigma\hat{p}_i - \sum_{k=0}^{n} e_{ik}\left[\hat{p}_k + [\sigma-1]\sum_{j=1}^{n} m_{jk}\hat{p}_j\right] = [\sigma-1]n_i\gamma \qquad (11)$$

The impact of PTA formation on the demand for $i$'s output thus depends on the extent of the net preferential access received by $i$.

Given the pre-PTA market shares and a value of $\sigma$, we can use (10) to solve for the relative price changes in the form:

$$\hat{p}_i = b_i\gamma; i=1,\dots,n \qquad (12)$$

where the numerical values of the $b_i$ will depend on all the parameters in (10) and (11). These solutions can then be substituted in (5B) to get expressions for the proportionate changes in trade flows as a function of $\gamma$.

This leads us to the estimating equation for the effects of PTAs on trade flows. Let $\bar{X}_{ij}$ denote the pre-PTA value of exports of $i$ to $j$. Then we can write:

$$X_{ij} = \bar{X}_{ij} + dX_{ij} = \bar{X}_{ij}\left[1 + \hat{X}_{ij}\right]$$

Which, using (5A) and the solutions for the price changes, gives us:

$$lnX_{ij} \cong ln\bar{X}_{ij} + \hat{X}_{ij}$$

$$= ln\bar{X}_{ij} + [\sigma - 1]\left[I_{ij} - \bar{m}_j\right]\gamma - [\sigma - 1]\left[b_i - \sum_{k=0}^{n} m_{kj}b_k\right]\gamma + b_j\gamma \qquad (13)$$

The first term is what the value of exports from $i$ to $j$ would be in the absence of PTAs (and will be captured by standard gravity variables below). The other terms capture the effects of PTAs on this trade. The first of these captures the preferential access effect of the trade cost changes on this trade flow – the effect normally attributed to the PTA dummy alone. If $i$ and $j$ are not members of a PTA ($I_{ij} = 0$) this term reduces to the direct trade diversion effects of the PTAs that the importing partner belongs to ($-[\sigma - 1]\bar{m}_j\gamma$). If $i$ and $j$ are members of the same PTA, then this term becomes $+[\sigma - 1]\left[1 - \bar{m}_j\right]\gamma$. The standard trade expansion effect is weakened to the extent that the importing country grants preferential access through this and other PTAs. Note that $\bar{m}_j$ will vary over time if $j$ varies its membership of PTAs. The remaining terms capture the indirect (relative price and expenditure) effects of the PTAs working through changes in output prices. The solutions from (12) can be inserted in (13) to provide a 'comprehensive' variable capturing the full effects of PTAs on bilateral trade flows. The estimated coefficient on this variable then provides an estimate of $\gamma$.

Before moving on to the empirics, it is worth taking a closer look at the 'trade diversion' effects' implied by our solutions. These are those PTA effects that appear in 'outside' bilateral trade flows (those not covered by a PTA). To do this we rewrite (13) isolating the importer-exporter pair ($ij$), the exporter alone ($i$) and the importer alone ($j$) variables. This gives:

$$lnX_{ij} = ln\bar{X}_{ij} + [\sigma - 1]I_{ij}\gamma - [\sigma - 1]b_i\gamma + \left\{b_j - [\sigma - 1]\left[\bar{m}_j - \sum_{k=0}^{n} m_{kj}b_k\right]\right\}\gamma \qquad (14)$$

The exporter effect on an outside flow arises from any change in the relative price of that exporter's output. If $i$'s relative price rises as a result of PTA membership, this will have a negative effect in all its export markets, which will appear as trade diversion in its outside flows. Of course if $i$'s relative price falls, its exports are encouraged. The importer effects on outside flows are more complex. If the relative price of the importer's own output increases, this raises its numeraire income and leads to increased imports from all sources. Otherwise, outside trade flows are discouraged to the extent that the importer offers preferential access ($\bar{m}_j$); but are encouraged to the extent that the network of PTAs has driven up the market-share-weighted average numeraire price of the products sold in this market. These then are the type of effects that the trade diversion dummy variables now commonly included in gravity equations are attempting to capture. For example, a dummy $D_{exp}$ that takes the value unity if the exporter in an outside flow is a PTA member and is zero otherwise, will pick up the effects of differences in the average relative price changes between PTA members and non-members. Suppose, for instance, that the relative prices of all PTA members increase, while those of non-members decline. Then (14) indicates that, other things equal, the outside flows where the exporter is a PTA member will fall, while the outside flows where the exporter is not a PTA member will increase. Estimation with $D_{exp}$ will then find trade diversion. A similar interpretation applies to the corresponding importer dummy.[11]

## 3. Tariffs and Trade Costs

We begin our empirical illustrations by using UNCTAD data on average MFN tariff rates in 2006 to calculate the effects of abolishing tariffs on those bilateral trade flows covered by PTAs.[12] Our intention here is mainly illustrative, since the evidence suggests that tariffs are but part of overall trade costs[13] and our average tariff data is partly contaminated by those PTAs in force in 2006. But the results are interesting in their own right and the exercise serves to demonstrate the workings of the model and to indicate the potential importance of the induced price effects. We then generalise this exercise adding estimates of exporters' trade costs based on average cif-fob differences for exports to Australia, Brazil and the USA from Sourdin and Pomfret (2012).

### *3.1 Average Tariffs*

We use average tariff data at the national level as estimates of the trade cost reductions associated with PTA membership. Let $\tau_j$ denote the proportional tariff rate applied to imports by country $j$ in the absence of a PTA. If a PTA is formed, partner exports enter $j$'s market duty free which corresponds to a proportionate reduction in iceberg trade costs of $\hat{t}_j = -\frac{\tau_j}{1+\tau_j}$, assuming that tariffs are the only trade costs to begin with. Then (5B) becomes:

$$\hat{X}_{ij} = \underbrace{-[\sigma-1][I_{ij}-\overline{m}_j]\hat{t}_j}_{preferential\ access\ effect} \underbrace{-[\sigma-1]\left[\hat{p}_i - \sum_{k=1}^{n} m_{kj}\,\hat{p}_k\right]}_{relative\ price\ effect} \underbrace{+\hat{p}_j}_{expenditure\ effect} \qquad (15)$$

[11] Interpretation of these differences in average effects can be problematic, particularly at this level of aggregation. Where dummies are included for individual PTAs (e.g. NAFTA), these averages may prove more representative. See Carrère (2006).

[12] Data sources and adjustments are described in the Appendix.

[13] See Anderson and van Wincoop (2004)

and the price effects are solved from the system of equations represented by (10), where the $i$th equation is now:

$$\sigma\hat{p}_i - \sum_{k=0}^{n} e_{ik}\left[\hat{p}_k + [\sigma - 1]\sum_{j=1}^{n} m_{jk}\hat{p}_j\right] = -[\sigma - 1]\sum_{k=0}^{n} e_{ik}\,[I_{ik} - \bar{m}_k]\hat{t}_k \qquad (16)$$

The market shares are calculated from GDP and trade data. The elasticity of substitution in consumption is assumed to be $\sigma = 5$ which seems to be a representative value.[14] We define our three effects:

*preferential access effect* $\quad -[\sigma - 1][I_{ij} - \bar{m}_j]\hat{t}_j$;

*relative price effect* $\quad -[\sigma - 1]\left[\hat{p}_i - \sum_{k=1}^{n} m_{kj}\,\hat{p}_k\right]$; and

*expenditure effect* $\quad \hat{p}_j$.

Table 1 shows the correlations among these effects and also with the proportionate changes in the trade flows. The Preferential Access Effect is reasonably highly correlated with the proportional changes in trade flows (0.77), but is not correlated with the other effects. The Relative Price and Expenditure Effects are also correlated with the proportional changes in trade flows, but to lesser degrees (0.66 and 0.50, respectively), and are moderately correlated with each other (0.65). Table 2 summarises the calculated proportionate changes in all bilateral trade flows ('all effects') and then separates these into those involving PTAs and outside flows. Our 'all effects' estimates indicate that PTAs have resulted in a 4% increase in bilateral trade flows on average, made up of a 29% increase in those flows covered by PTAs and a 1% reduction in outside flows, on average.

Obviously the most computationally demanding task in those calculations is determining the induced price effects. How large are the errors, on average, if we ignore these? In Table 2 we also summarise the calculations if we ignore the induced price effects ('Pref. Acc. Eff. only') and if we simplify even further and include only the own-tariff effect on bilateral trade flows covered by PTAs[15] ($-[\sigma - 1]I_{ij}\hat{t}_j$). The 'Pref. Acc. Eff. only' averages underestimate the overall and PTA averages, but overestimate the magnitude of the fall in outside flows. The 'own tariff only' averages err in the opposite direction, with a 5% increase in bilateral trade on average, made up of a 31% increase in PTA trade and no change in outside trade by construction. Table 3 shows

[14] Anderson and van Wincoop (2004) consider elasticities in the range 5 to 10, with a 'preferred' value of 8. Carrère (2006) uses an elasticity of 4. The results for an elasticity of 8 are qualitatively similar, and are available from the authors.

[15] Obviously in this case we are assuming no changes in non-PTA trade flows. If we further assumed that $\hat{t}_j$ was the same for all j, then this would broadly equivalent to the use of a PTA dummy in the gravity equation below.

that the 'TPAE only' and 'own-tariff only' calculated changes are highly correlated with each other (0.97) and moderately correlated with the proportional changes in trade flows overall (0.77 and 0.69, respectively), although the latter largely reflects the within PTA trade flows (0.84 and 0.79).

A further advantage of these model based calculations, is that they enable us to comment on the distribution of PTA effects. Table 2 includes minimum and maximum trade changes in each category. The interesting feature here is that, once general equilibrium (price) effects are taken into account, not all within PTA flows increase and not all outside flows fall. A concentration on average effects neglects this 'distributional aspect' and while considering TPAE and own-tariff only may approximate the average, they can only generate increased trade flows within the PTA and reduced trade flows outside.

*3.2 Average Tariffs plus the Cif-Fob Gap*

One drawback of the calculations just completed, is that the magnitude of the PTA-induced trade cost reduction depends only on the tariff of the importer. We can generalise these outcomes somewhat by using average cif-fob gap data for each exporter from Sourdin and Pomfret (2012) as estimates of non-tariff related trade costs. Let $v_i$ denote the estimated trade cost for exporter $i$. Now the proportionate reduction in trade costs on bilateral exports from country $i$ to country $j$ if they form a PTA is given by:

$$\hat{t}_{ij} = -\frac{\tau_j}{1+v_i+\tau_j}$$

Since $\hat{t}_{ij}$ depends on both $v_i$ and $\tau_j$, we will not have $\hat{t}_{ij} = \hat{t}_{ji}$ in general. We then calculate $T_{ij}$ and $\bar{T}_i$ as above, and solve for the induced price changes using (10). Our three effects become:

*preferential access effect* $\quad -[\sigma - 1]\left[\hat{t}_{ij}I_{ij} - \sum_{k=0}^{n} m_{kj}\,\hat{t}_{kj}I_{kj}\right]$;

*relative price effect* $\quad -[\sigma - 1]\left[\hat{p}_i - \sum_{k=1}^{n} m_{kj}\,\hat{p}_k\right]$; and

*expenditure effect* $\quad \hat{p}_j$.

The correlations amongst these effects and with the proportionate changes in the trade flows are also shown in Table 1. The pattern is identical and the magnitudes very similar to those when only tariff costs are considered. The price effects are slightly more highly correlated with each other. As one would expect, since we have effectively reduced the magnitude of the PTA trade cost reductions, the calculated changes in trade volumes are smaller. Table 2 (all effects) shows that the average change in bilateral trade flows is 2.7%; composed of a 26% increase in PTA flows and a 2% reduction in outside flows. Again, restricting attention to the preferential access effect underestimates the changes in average and inside PTA flows, and overestimates the magnitude of the change in outside flows. The correlations in Table 3 are very similar to the case where only tariff costs were considered.

The caveat on the ability of the restricted measures to capture negative PTA changes and positive outside changes continues to apply, as is shown by the box-plots in Figure 1. In this non-parametric representation, the dimensions of the box are the second and third quartiles of the changes and the line in the box is the median. The upper horizontal line ('whisker') is the largest observation that is less than or equal to the 'upper inner fence' (the third quartile plus 1.5*IQR - where IQR is the interquartile range). The lower whisker is the smallest observation that is greater than or equal to the lower inner fence (defined as the first quartile minus 1.5*IQR). The dots are then the outliers. It is apparent from Figure 1 that, while the restricted measures generate median outcomes that are close to the actual medians for both within and outside PTA trade, they distort the distribution of changes in both cases. The preferential access effect and own-tariff effects give similar distributions of changes for within PTA trade flows, though they omit all the reductions and the larger positive outliers from the actual changes. The actual changes in the outside PTA trade flows appear to be quite symmetric around a small negative median. Neither restricted measure can come close to replicating this distribution.

*Summary*: This sub-section has considered a relatively simple model where each country produces a unique output and where sufficient data is available to calculate the PTA induced trade cost reductions on bilateral trade flows. In this model we have shown that omitting the general equilibrium effects of PTA membership produces relatively small errors in estimates of average changes in within PTA trade flows. Taking into account the full general equilibrium effects of PTAs gave us an average increase of within PTA trade flows of 26 to 29%. When we restricted attention to the direct trade cost reducing effects of PTAs (i.e. our 'own-tariff-only' case), we overestimated the average increase of within PTA trade flows, but only by 2 to 3 percentage points. Alternatively, when we modified the direct trade cost reducing effect to allow for the preferences offered by the importer (i.e. the Preferential Access Effect), then we underestimated the average increase of within PTA bilateral trade flows, but again only by 1 to 2 percentage points. But while the estimated average changes might be similar, these simplifications cannot replicate the dispersion of bilateral trade volume changes. Our results also showed that some within-PTA trade flows were reduced, while some outside flows were increased, as a consequence of the general equilibrium effects of the PTAs in force in 2006.

## 4. Gravity estimates

As noted in the Introduction, most estimates of the effects of PTA membership on bilateral trade flows are not model-based, but instead follow the pragmatic approach of adding a PTA dummy to the 'many-model-encompassing' gravity equation. In this section we therefore add the general equilibrium variables derived from the model above to a standard gravity equation estimated on bilateral trade flows. While we still use the model to calculate the price change variables, we can no longer employ the tariff and trade cost variables used above (for which we have single observations), and instead assume that PTA membership gives a common (but unknown) proportional reduction in bilateral trade costs (our $\gamma$ from Section 2). This trade cost reduction is the same for all PTAs (i.e. it does not depend on the identity of the trading parties), and will be estimated by the gravity equation. Since our focus is on market access, we follow the majority of the literature in using the value of exports as our dependent variable. We take a fairly standard specification of the gravity equation and augment it with our PTA related variables, obtaining:

$$lnEXP_{ijt} = \alpha_0 + \alpha_1 lnGDP_{it} + \alpha_2 lnGDP_{jt} + \alpha_3 lnPOP_{it} + \alpha_4 lnPOP_{jt} + \alpha_5 lnDIST_{ij} + \alpha_6 LANG_{ij} + \alpha_7 ADJ_{ij} + \alpha_8 LOCK_{ij} + \Gamma Z_t + \delta_{i(t)} + \omega_{j(t)} + \tau_t + \vartheta_{ij} + u_{ijt} \quad (17)$$

where $EXP_{ij}$ is the value of merchandise trade flow imported by country $j$ from exporter $i$, $GDP_i$ ($GDP_j$) is the level of nominal gross domestic product of country $i$ ($j$), $POP_i$ ($POP_j$) is the population of country $i$ ($j$), $DIST_{ij}$ is the distance between economic centres of countries $i$ and $j$, $LANG_{ij}$ is a binary variable equal to one if countries $i$ and $j$ share a common language, $ADJ_{ij}$ is a binary variable equal to one if countries $i$ an $j$ share a common border, $LOCK_{ij}$ is a variable accounting for whether none, one or both countries are landlocked[16], $\delta_{i(t)}$, $\omega_{j(t)}$, and $\tau_t$ are exporter, importer and time fixed effects respectively, where the former two may also be time dependent[17], and $\vartheta_{ij}$ is a bilateral pair dummy. When we include the bilateral pair dummies the coefficients on distance and other bilateral-pair time-invariant variables geographical variables cannot be estimated and so these variables have to be excluded from (17). All variables are included in log form,[18] with the exception of the PTA variables and the dummy variables. We include the PTA effects, denoted by vector $Z_t$ in (17) above, both individually and collectively. Where we need a value for the elasticity of substitution, we assume $\sigma = 5$ as before.

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[16] $LOCK_{ij}$ takes on the value 0, 1 or 2 depending on whether none, one or both countries are landlocked respectively.
[17] As discussed above the inclusion of country-pair fixed effects is used to account for the multilateral resistance terms. In a panel context however we may need to take account of the time varying nature of these terms through the inclusion of importer-time and exporter-time fixed effects (see Baldwin and Taglioni, 2006).
[18] That is, we follow the bulk of the literature in focussing on the intensive margin and exclude zero trade flows from the analysis.

For comparison purposes, it is convenient to define all three PTA effects so that each of their coefficients provides an estimate of $\gamma$. We therefore define the

*preferential access effect* $[\sigma - 1][I_{ijt} - \bar{m}_{jt}]$;

*relative price effect* $-[\sigma - 1][b_{it} - \sum_{k=1}^{n} m_{kjt} b_{kt}]$; and

*expenditure effect* $b_{jt}$.

If we combine the two price effects and then all three effects we have the

*combined price effects* = *relative price effect* + *expenditure effect*; and

*total PTA effects* = *preferential access effect* + *combined price effects*

The coefficient on the Total PTA Effects variable is then our 'preferred' estimate of the proportionate reduction in trade costs as a consequence of PTA membership. Since we have stepped away from the model, we also disaggregate the preferential access effect into its two components – the PTA dummy and the extent of preferential access offered by the importer. The coefficient on the dummy then estimates the trade creating impact of PTA membership and the coefficient on $\bar{m}_{jt}$ the trade diversion impact of preferential access, other things equal.

Some information on the calculated price change effects are provided in Table 4. The data used for these calculations are for 2006 and the variables listed are: $b_i$ the coefficient on $\gamma$ in the proportional price change equation (12), which captures the change in the relative price of country $i$'s output; $\theta_i$ which is country $i$'s share of world income; $\bar{m}_i$ which captures the extent of the preferences offered by country $i$; $\bar{e}_i$ which captures the preferences received by country $i$; $n_i$ which captures the net preferences received by country $i$; and $N_i$ the number of PTAs in which country $i$ is a member. Of these variables, only the calculated relative price changes depend on the assumed value of $\sigma$, and in Table 4 we include correlations of calculated relative price changes for $\sigma$ = 5, 8 and 10. We draw several conclusions from Table 4. First, that the calculated price effects are very highly correlated, indicating that the chosen value of $\sigma$ is not critical in this regard. Second, that the price effects are moderately correlated with the preferences received, uncorrelated with the preferences offered, and most highly correlated with net preferences received. Third, relative country size is not correlated with any price effects, nor with preferences received or offered. Fourth, the number of PTAs to which a country belongs is not highly correlated with any of the other variables in Table 4. Its highest correlation is with preferences received (0.38). Finally, while the preferences received and offered are significantly positively correlated, the correlation of 0.68 is not as high as one might have imagined.

Table 5 presents the correlation matrix for our PTA effects. If the preferential access, relative price and expenditure effects were all highly correlated, then the estimated coefficients when the preferential access effect was included on its own would indicate the sign and significance of the overall PTA effect, although its coefficient would be an overestimate of $\gamma$. Unfortunately, while the relative price and expenditure effects are reasonably correlated (0.71), they are uncorrelated with the preferential access effect as before. If we decompose the preferential access effect, we find that the PTA dummy is highly correlated (0.69) with the total PTA effect, but that preferences offered are not highly correlated with any of the other effects in this Table.

The estimation results are presented in four Tables. All include time effects. Table 6 adds importer and exporter fixed effects, which will capture the time invariant components of the trading partners' multilateral resistance terms, but not the potential endogeneity of PTA choice. In Table 7 these importer and exporter fixed effects are time varying, allowing them to capture exogenous changes in multilateral resistance terms but also introducing the possibility that they may pick up the price effects of PTA formation to some extent. Table 8 includes country pair fixed effects, to deal with the potential endogeneity of PTA membership, but does not allow for the multilateral resistance terms. Finally Table 9 includes time-varying importer and exporter as well as country-pair fixed effects. These deal with the PTA endogeneity issue and capture changes in the multilateral resistance terms, some of which may be PTA induced. We would expect that this pattern of inclusion and exclusion of fixed effects should see the estimated PTA effects decline as we move to higher numbered tables, and this expectation is confirmed in the results.

Since the patterns of results are very similar across the tables, we can discuss them collectively. The coefficients on the gravity variables are consistent, with the only anomaly being the opposing signs on population of the importer and exporter. The first regression in each table adds a PTA dummy to the gravity equation as has been standard in the literature. The estimated coefficient on the PTA dummy is always positive and significant, but declines in magnitude as we strengthen the country fixed effects. It predicts an increase in bilateral trade of between 27.8% and 52.3% for PTA members. The preferential access effect derived in Section 2 modifies the PTA dummy by subtracting a term that captures the degree of preferential access offered by the importer. As noted above, we introduce this change in two stages. Initially we simply add the $\overline{m}_j$ variable in regression (2), which tends to increase the coefficient on the PTA dummy somewhat, while the estimated coefficient on importer preferential access is negative and significant as expected. These results indicate that PTA membership itself tends to increase a bilateral trade flow by 28% to 52% as before, but that this number should be corrected downwards to the extent that the importer offers preferential access in general (e.g. if 10% of sales in the importer's market have preferential access, the corresponding corrections are -3.6% and -2.2%).[19] If we combine them into our preferential access variable $(I_{ij} - \overline{m}_j)$ as in regression (3), the estimated coefficient on the combined variable is insignificant, however. Thus if the PTA dummy and the preferential access offered by the importer are the only PTA variables to be included, it seems best to include them separately.

In regression (4) in each table we include the preferential access, relative price and expenditure effects of PTA membership separately. These variables have been defined so that all are expected to have positive coefficients, and, indeed, were the data to fit the model, these coefficients should be equal to the proportional trade cost reduction due to PTA membership. Unsurprisingly, given the correlations in Table 5, these expectations are not met in full. The preferential access effect has a positive and significant coefficient in each case. The expenditure and relative price effects have opposite signs, so that while the expenditure effect is mostly positive and always significant, the relative price effect is typically negative and is not always significant. Combining the 'price' effects gives us the outcomes reported in regression (5), where the estimated coefficients on the preferential access effect are almost identical to those in regression (4), but the estimated coefficients on the combined price effects vary in sign, being significant in Table 7 only.

When we move to our 'preferred' specification, which includes a single variable combining the full effects of PTAs in the gravity equation, we get the results reported in regression (6). As noted in the previous section, the coefficient on this variable provides an estimate of the proportional reduction in trade costs implied by PTA membership on average. These estimates are statistically significant and range from 8.21% to 2.65% in terms of their estimated trade cost reductions. Our variable is constructed so as to capture the full effects of PTAs on the multilateral resistance terms, so the inclusion of time varying importer and exporter fixed effects will be capturing any other influences on trade costs. The country-pair fixed effects should take account of unobserved heterogeneity that might promote PTA membership, and their inclusion indicates trade cost reductions at the lower end of the range (just under 3%). To translate this estimated trade cost reduction into a volume of trade effect, we must multiply the estimate of $\gamma$ by the corresponding calculated total PTA effect. The outcomes for the mean Total PTA Effect are shown in Table 10. PTAs have resulted in an average increase in bilateral trade volumes of 0.6% to 1.88%, composed of an average increase of 9.76% to 33.42% for trade within PTAs and a reduction of 0.97% to

[19] When Fugazza and Nicita (2013) include a PTA dummy along with their two preferential access variables its estimated coefficient indicates that PTA membership gives a 35% increase in bilateral trade, other things equal.

3% in average trade outside of PTAs. Generally, these estimates are much smaller than those obtained using a PTA dummy.[20]

## 5. Conclusions

Our objective in this paper has been to extend the empirical analysis of the effects of PTA membership on bilateral trade flows, by deriving more inclusive indicators of the likely impact on trade of PTA membership. In particular, we sought to capture the potential trade effects that are missed by the standard membership dummy. We began by considering a standard trade model that generates a gravity equation to explain bilateral trade. By deriving an expression for the proportional change in a bilateral trade flow resulting from changes in trade costs, we were able to identify three effects. The preferential access effect captured the proportional change in trade flows due to the direct impact of the trade cost changes. It is positive (negative) if the trade costs directly applying to a bilateral trade flow fall by more (less) then the importer-market-share weighted average of all trade costs to this importer. This effect will be positive for an inside PTA trade flow and negative for an outside flow. The remaining effects depended on the induced changes in (relative) prices. The relative price effect was a counterpart to the preferential access effect, with proportional relative price changes replacing proportional direct trade cost changes. This effect will be positive (negative) for a particular bilateral trade flow if the exporter's price falls (rises) relative to an importer-market-share weighted price index. Given that the exporters with the largest trade costs reductions are most likely to experience increased foreign demand for their output leading to an increase in its relative price, one might naturally presume a negative correlation between the preferential access and relative price effects. In fact these terms are found to be uncorrelated, indicating that in general equilibrium the relative price changes are not simply acting to moderate the effects of the direct cost changes. Finally, the expenditure effect captured the change in trade flows induced by the changes in the importer's numeraire income. Given our assumption of exogenous real output, this effect will be positive if the relative price of the importer's output rises, and negative if it falls.

Our first application of these concepts used average tariff data for importers and cif-fob gap data for exporters to calculate proportional trade cost reductions for each within PTA trade flow. The model was then used to calculate the induced relative price changes, allowing the full trade effects of PTA membership to be determined. We found that while the two price effects were positively correlated, they were uncorrelated with the preferential access effect. The results indicated an

[20] Both are similar to those Fugazza and Nicita (2013) based on the estimated coefficients from including their preferential access variables in a gravity equation. They estimate the average increase in bilateral trade due to preferential trade (versus MFN tariffs) to be between 1.25 and 3.3%.

average increase in within PTA trade flows of 26 to 29% and an average reduction in outside PTA trade flows of 1 to 2%. But these averages masked a diversity of individual experiences, with some within PTA trade flows falling, and some outside trade flows increasing. When we confined attention to the preferential access effect, because it is relatively straightforward to calculate, we found that it under-predicted the full changes in trade flows. It also failed to reflect the diversity in outcomes, since it predicts only increased within PTA trade flows and only decreased outside trade flows. Restricting attention even further to just the direct trade cost reductions on within-PTA flows over-predicted the average change in within-PTA trade flows.

Our second application followed the pragmatic approach popular in the literature and added our variables to a standard gravity equation, in our case under the assumption that a PTA results in an unknown but common proportional reduction in trade costs among members. Our (model-based) calculations of the relative price changes show them to be much more highly correlated with preferences received than preferences given, which is consistent with an emphasis on market access. When all PTA effects were combined and included as a single variable, we estimated that PTA membership resulted in a bilateral trade cost reduction between 3% and 8% on average, which translated into an average increase in within PTA flows of 10% to 33%, and an average reduction in outside PTA trade flows of 1% to 3%. The corresponding estimates for within PTA trade flows based on a PTA dummy were average increases of 28% to 52%.

In combination, our results lead us to draw the following conclusions. First, estimates based on the coefficient on a standard PTA dummy are likely to significantly over-estimate the actual effects of PTA membership on bilateral trade flows. Second, our model-based results indicate that making some allowance for trade diversion by adjusting the PTA dummy variable by the extent of preferential access offered by the importer (our $\overline{m}_j$) will give a better approximation to the overall effects of PTA membership. Our gravity results suggest that this adjustment will be more effective if the two variables are entered separately, however. Third, the average changes cover a wide dispersion of individual outcomes, including falls in some within-PTA trade flows and increases in some outside-PTA flows. Finally, the relative price effects of PTA formation seem to be uncorrelated with the preferential access effects and important empirically. Since identification of these price effects requires modeling, they are only likely to be explicitly taken into account when the PTA analysis is conducted within a formal (e.g. computable general equilibrium) model. In a gravity equation the price effects will be consigned to the fixed effects, and it is important to recall their presence there when interpreting the PTA outcomes.

**Appendix.**

Data are from standard sources. The GDP and population of the importer and exporter are from the World Development Indicators (2008) dataset. Data on distance, common language and adjacency are from CEPII.[21] The trade data is taken from COMTRADE and in our analysis we measure bilateral exports from $i$ to $j$ from the reported imports of country $j$. The dataset includes up to 174 countries over the period 1988-2006. Data on PTAs is taken from the WTO website[22] and complemented with information from the global Preferential Trade Agreements (GPTA) Database.[23]

The average tariff data is from the UNCTAD TRAINS database and is measured as the average applied import tariff. We have used 2006 values, or the nearest year when 2006 is not available.

The (cif-fob) trade cost data is from Sourdin and Pomfret (2012). They report (simple) average cif-fob difference data for a large number of exporting countries using customs data from Australia, Brazil and the US. Neighbouring country data was used for countries in our sample that are not reported by Sourdin and Pomfret.

In Section 2, we showed that pre-PTA market shares were the appropriate weights on the trade cost changes. Unfortunately, PTAs are present in every year of our sample and our sample's country coverage increases in the later years. This precludes us from using early year data to calculate market shares. Instead we use 2006, our year of most complete coverage, recognising that these market shares are somewhat contaminated by the PTAs in force, and hence our market-access effects are exaggerated to some degree.

The Anderson and van Wincoop (2003) model is a single-period, real model and therefore assumes that each country's trade is balanced. The world that generates the data is not so constrained. In calculating the market shares our major concern has been that they sum to unity. Thus for each country domestic sales are measured, using National Income data, as GDP minus exports. Total demand is then domestic sales plus imports. Importing country $j$'s market shares are $m_{ij} = \frac{exports_{ij}}{total\ demand_j}$; while exporting country $i$'s sales shares are $e_{ij} = \frac{exports_{ij}}{GDP_i}$.

[21] http://www.cepii.fr/anglaisgraph/bdd/distances.htm
[22] http://rtais.wto.org/UI/PublicAllRTAList.aspx
[23] The database is available at http://www.dartmouth.edu/~traded/trade_database.html. The reason for considering alternative sources is that the WTO dataset only includes PTAs in force, thus excluding a number of PTAs that are no longer in force, but that would have been in the period of interest – e.g. the PTAs agreed between the EU-15 and Romania, Bulgaria and others in the 1990s, but which are no longer in force now that these countries are members of the EU.

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Table 1: Correlations of the Tariff Effects

| | Tariffs only | | | Tariffs plus cif-fob difference | | |
|---|---|---|---|---|---|---|
| | Trade Flow | Pref. Acc. Eff. | Rel. Price Eff. | Trade Flow | Pref. Acc. Eff. | Rel. Price Eff. |
| Pref. Acc. Eff. | 0.7672 | 1 | | 0.7484 | 1 | |
| Rel. Price Eff. | 0.6617 | 0.0335 | 1 | 0.6832 | 0.0326 | 1 |
| Expend. Eff. | 0.4979 | 0.0286 | 0.6527 | 0.5376 | 0.0268 | 0.7071 |

Table 2: Summary of Calculated Changes in Bilateral Trade Flows

| **Tariffs Only** | | | | | |
|---|---|---|---|---|---|
| Variable | Obs. | Mean | Std. Dev. | Min. | Max. |
| All Bilateral Flows | | | | | |
| All Effects | 28561 | 0.03926 | 0.18805 | -0.83129 | 1.63862 |
| Pref. Acc. Eff. only | 28561 | 0.02393 | 0.14012 | -0.20354 | 0.92780 |
| Own tariff only | 28561 | 0.05231 | 0.14284 | 0 | 0.92780 |
| PTA Flows only | | | | | |
| All Effects | 4818 | 0.29037 | 0.20103 | -0.32588 | 1.63862 |
| Pref. Acc. Eff. only | 4818 | 0.27485 | 0.18937 | 0 | 0.92780 |
| Own tariff only | 4818 | 0.31009 | 0.20253 | 0 | 0.92780 |
| Outside Flows only | | | | | |
| All Effects | 23743 | -0.0117 | 0.11001 | -0.83129 | 0.81111 |
| Pref. Acc. Eff. only | 23743 | -0.0270 | 0.03119 | -0.20354 | 0 |
| Own tariff only | 23743 | 0 | 0 | 0 | 0 |
| | | | | | |
| **Tariffs plus cif-fob difference** | | | | | |
| Variable | Obs. | Mean | Std. Dev. | Min. | Max. |
| All Bilateral Flows | | | | | |
| All Effects | 28561 | 0.02735 | 0.18272 | -0.83573 | 1.57126 |
| Pref. Acc. Eff. only | 28561 | 0.02252 | 0.13275 | -0.19675 | 0.92780 |
| Own tariff only | 28561 | 0.04952 | 0.13540 | 0 | 0.92780 |
| PTA Flows only | | | | | |
| All Effects | 4818 | 0.26425 | 0.19256 | -0.31641 | 1.57126 |
| Pref. Acc. Eff. only | 4818 | 0.25987 | 0.17994 | 0 | 0.92780 |
| Own tariff only | 4818 | 0.29353 | 0.19251 | 0 | 0.92780 |
| Outside Flows only | | | | | |
| All Effects | 23743 | -0.02073 | 0.13762 | -0.83530 | 0.76508 |
| Pref. Acc. Eff. only | 23743 | -0.02564 | 0.02962 | -0.19675 | 0 |
| Own tariff only | 23743 | 0 | 0 | 0 | 0 |

Table 3: Correlations of calculated changes in bilateral trade flows

| | Tariffs only | | Tariffs plus cif-fob difference | |
|---|---|---|---|---|
| | All effects | Pref. Acc. Eff. only | All effects | Pref. Acc. Eff. only |
| All Bilateral Trade Flows | | | | |
| Pref. Acc. Eff. only | 0.7672 | 1 | 0.7484 | 1 |
| Own tariff only | 0.6899 | 0.9737 | 0.6624 | 0.9735 |
| PTA Flows only | | | | |
| Pref. Acc. Eff. only | 0.8388 | 1 | 0.8073 | 1 |
| Own tariff only | 0.7855 | 0.9836 | 0.7447 | 0.9823 |
| Outside Flows only | | | | |
| Pref. Acc. Eff. only | 0.5723 | 1 | 0.5976 | 1 |
| Own tariff only | | | | |

Table 4: Correlation Matrix for 2006

| Variables | | Rel. Price Changes ($b_i$) | | | Pref Off'd ($\bar{m}_i$) | Pref Rec'd ($\bar{e}_i$) | Net Pref ($n_i$) | Income Share ($\theta_i$) |
|---|---|---|---|---|---|---|---|---|
| | | $\sigma = 5$ | $\sigma = 8$ | $\sigma = 10$ | | | | |
| Rel. Price. Changes ($b_i$) | $\sigma = 8$ | 0.9996 | 1 | | | | | |
| | $\sigma = 10$ | 0.9992 | 1 | 1 | | | | |
| Pref Off'd ($\bar{m}_i$) | | 0.0106 | 0.0147 | 0.0158 | 1 | | | |
| Pref Rec'd ($\bar{e}_i$) | | 0.5590 | 0.5520 | 0.5496 | 0.6773 | 1 | | |
| Net Pref ($n_i$) | | 0.7087 | 0.6945 | 0.6901 | -0.1785 | 0.5897 | 1 | |
| Income Share ($\theta_i$) | | 0.0457 | 0.0432 | 0.0424 | -0.0665 | -0.0193 | 0.0518 | 1 |
| # PTAs ($N_i$) | | 0.2056 | 0.2050 | 0.2047 | 0.2874 | 0.3829 | 0.1777 | -0.0224 |

Table 5: Correlations of PTA Effects 2006 [$\sigma$=5]

| | PTA Dummy | Preferential Access Effect | Relative Price Effect | Expenditure effect | Preferences Offered ($\bar{m}_j$) |
|---|---|---|---|---|---|
| Preferential Access Effect | 0.9683 | 1 | | | |
| Relative Price Effect | -0.0000 | -0.0019 | 1 | | |
| Expenditure effect | 0.0621 | 0.0589 | 0.7071 | 1 | |
| Preferences Offered ($\bar{m}_j$) | 0.0853 | 0.0845 | -0.0075 | 0.000 | 1 |
| Total PTA Effect | 0.6948 | 0.7158 | 0.6927 | 0.5871 | 0.0554 |

Table 6: Time and Importer/Exporter Fixed effects

| | (1)<br>ln $EXP$ | (2)<br>ln $EXP$ | (3)<br>ln $EXP$ | (4)<br>ln $EXP$ | (5)<br>ln $EXP$ | (6)<br>ln $EXP$ |
|---|---|---|---|---|---|---|
| $lnGDP_i$ | 0.379*** | 0.379*** | 0.386*** | 0.380*** | 0.379*** | 0.369*** |
| | (0.0202) | (0.0202) | (0.0203) | (0.0203) | (0.0203) | (0.0203) |
| $lnGDP_j$ | 0.809*** | 0.812*** | 0.819*** | 0.817*** | 0.816*** | 0.824*** |
| | (0.0236) | (0.0236) | (0.0237) | (0.0236) | (0.0236) | (0.0236) |
| $lnPOP_i$ | -0.850*** | -0.849*** | -0.919*** | -0.833*** | -0.851*** | -1.040*** |
| | (0.0745) | (0.0745) | (0.0745) | (0.0764) | (0.0757) | (0.0747) |
| $lnPOP_j$ | 0.587*** | 0.565*** | 0.536*** | 0.586*** | 0.550*** | 0.752*** |
| | (0.0769) | (0.0775) | (0.0777) | (0.0804) | (0.0786) | (0.0777) |
| $lnDIST$ | -1.393*** | -1.393*** | -1.473*** | -1.393*** | -1.393*** | -1.420*** |
| | (0.00678) | (0.00679) | (0.00639) | (0.00679) | (0.00679) | (0.00668) |
| $ADJ$ | 0.552*** | 0.552*** | 0.609*** | 0.552*** | 0.552*** | 0.571*** |
| | (0.0293) | (0.0293) | (0.0295) | (0.0293) | (0.0293) | (0.0294) |
| $LANG$ | 0.932*** | 0.932*** | 0.945*** | 0.932*** | 0.932*** | 0.936*** |
| | (0.0135) | (0.0135) | (0.0136) | (0.0135) | (0.0135) | (0.0135) |
| $LOCK$ | -0.439 | -0.416 | -0.429 | -0.414 | -0.390 | -0.610 |
| | (105.2) | (3623.7) | (158.9) | (227.5) | (96.10) | (140.8) |
| PTA Dummy ($I$) | 0.421*** | 0.423*** | | | | |
| | (0.0124) | (0.0125) | | | | |
| Importer Pref ($\bar{m}$) | | -0.222** | | | | |
| | | (0.107) | | | | |
| $I - \bar{m}$ | | | -0.111 | | | |
| | | | (0.106) | | | |
| PAE | | | | 0.106*** | 0.106*** | |
| | | | | (0.00314) | (0.00314) | |
| RE | | | | -0.00664 | | |
| | | | | (0.00616) | | |
| EE | | | | 0.0867** | | |
| | | | | (0.0384) | | |
| CE | | | | | 0.00154 | |
| | | | | | (0.00459) | |
| TE | | | | | | 0.0707*** |
| | | | | | | (0.00268) |
| Observations | 265,054 | 265,054 | 265,054 | 265,054 | 265,054 | 265,054 |
| R-Squared | 0.738 | 0.738 | 0.737 | 0.738 | 0.738 | 0.737 |
| F-Test | 2051.3**** | 2045.7*** | 2039.6*** | 2040.1*** | 2045.7*** | 2047.5*** |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Time and Importer-Time/Exporter-Time Fixed effects

| | (1)<br>$\ln EXP$ | (2)<br>$\ln EXP$ | (3)<br>$\ln EXP$ | (4)<br>$\ln EXP$ | (5)<br>$\ln EXP$ | (6)<br>$\ln EXP$ |
|---|---|---|---|---|---|---|
| $lnGDP_i$ | 0.223*** | 0.223*** | 0.219*** | 0.229*** | 0.225*** | 0.212*** |
| | (0.0363) | (0.0363) | (0.0364) | (0.0363) | (0.0363) | (0.0363) |
| $lnGDP_j$ | 0.649*** | 0.648*** | 0.645*** | 0.648*** | 0.645*** | 0.661*** |
| | (0.0443) | (0.0443) | (0.0445) | (0.0443) | (0.0443) | (0.0443) |
| $lnPOP_i$ | -0.860*** | -0.860*** | -0.903*** | -0.773*** | -0.831*** | -1.035*** |
| | (0.255) | (0.255) | (0.255) | (0.256) | (0.256) | (0.255) |
| $lnPOP_j$ | 0.449* | 0.414 | 0.392 | 0.454* | 0.386 | 0.538** |
| | (0.263) | (0.263) | (0.264) | (0.263) | (0.263) | (0.263) |
| $lnDIST$ | -1.402*** | -1.402*** | -1.479*** | -1.401*** | -1.402*** | -1.417*** |
| | (0.00676) | (0.00676) | (0.00637) | (0.00676) | (0.00676) | (0.00670) |
| $ADJ$ | 0.548*** | 0.548*** | 0.604*** | 0.549*** | 0.548*** | 0.560*** |
| | (0.0294) | (0.0294) | (0.0296) | (0.0294) | (0.0294) | (0.0294) |
| $LANG$ | 0.932*** | 0.931*** | 0.944*** | 0.932*** | 0.931*** | 0.934*** |
| | (0.0134) | (0.0134) | (0.0135) | (0.0134) | (0.0134) | (0.0134) |
| $LOCK$ | 1.460 | 1.524 | 1.540 | 1.409 | 1.526 | 1.578 |
| | (3356.0) | (126.3) | (84.34) | (3356.0) | (88.34) | (3358) |
| PTA Dummy | 0.408*** | 0.410*** | | | | |
| ($I$) | (0.0126) | (0.0126) | | | | |
| Importer Pref | | -0.358* | | | | |
| ($\bar{m}$) | | (0.193) | | | | |
| $I - \bar{m}$ | | | 0.00762 | | | |
| | | | (0.193) | | | |
| PAE | | | | 0.102*** | 0.102*** | |
| | | | | (0.00316) | (0.00316) | |
| RE | | | | -0.0419*** | | |
| | | | | (0.00937) | | |
| EE | | | | 0.253*** | | |
| | | | | (0.0594) | | |
| CE | | | | | -0.0143** | |
| | | | | | (0.00691) | |
| TE | | | | | | 0.0821*** |
| | | | | | | (0.00288) |
| Observations | 265,054 | 265,054 | 265,054 | 265,054 | 265,054 | 265,054 |
| R-Squared | 0.745 | 0.745 | 0.744 | 0.745 | 0.745 | 0.745 |
| F-Test | 606.9*** | 606.4*** | 603.7*** | 606.0*** | 606.4*** | 606.2*** |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Time and Country Pair Fixed Effects

| | (1) $\ln EXP$ | (2) $\ln EXP$ | (3) $\ln EXP$ | (4) $\ln EXP$ | (5) $\ln EXP$ | (6) $\ln EXP$ |
|---|---|---|---|---|---|---|
| $lnGDP_i$ | 0.419*** | 0.418*** | 0.425*** | 0.416*** | 0.417*** | 0.418*** |
| | (0.0130) | (0.0130) | (0.0130) | (0.0130) | (0.0130) | (0.0130) |
| $lnGDP_j$ | 0.892*** | 0.897*** | 0.900*** | 0.896*** | 0.897*** | 0.901*** |
| | (0.0155) | (0.0155) | (0.0155) | (0.0155) | (0.0155) | (0.0155) |
| $lnPOP_i$ | -0.273*** | -0.268*** | -0.345*** | -0.297*** | -0.277*** | -0.382*** |
| | (0.0510) | (0.0510) | (0.0508) | (0.0519) | (0.0516) | (0.0509) |
| $lnPOP_j$ | 0.768*** | 0.740*** | 0.717*** | 0.712*** | 0.751*** | 0.807*** |
| | (0.0540) | (0.0545) | (0.0545) | (0.0560) | (0.0548) | (0.0546) |
| PTA Dummy (*I*) | 0.297*** | 0.313*** | | | | |
| | (0.0188) | (0.0192) | | | | |
| Importer Pref $(\overline{m})$ | | -0.303*** | | | | |
| | | (0.0764) | | | | |
| $I - \overline{m}$ | | | 0.0442 | | | |
| | | | (0.0748) | | | |
| PAE | | | | 0.0784*** | 0.0781*** | |
| | | | | (0.00479) | (0.00479) | |
| RE | | | | 0.0131*** | | |
| | | | | (0.00413) | | |
| EE | | | | -0.0864*** | | |
| | | | | (0.0269) | | |
| CE | | | | | 0.00405 | |
| | | | | | (0.00315) | |
| TE | | | | | | 0.0265*** |
| | | | | | | (0.00262) |
| Observations | 265,054 | 265,054 | 265,054 | 265,054 | 265,054 | 265,054 |
| Within R-Squared | 0.087 | 0.087 | 0.086 | 0.087 | 0.087 | 0.087 |
| F-Test | 1002*** | 960.9*** | 990.0*** | 923.0*** | 961.0*** | 994.9*** |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Time, Country-Pair and Importer-Time/Exporter-Time Fixed effects

| | (1)<br>$\ln EXP$ | (2)<br>$\ln EXP$ | (3)<br>$\ln EXP$ | (4)<br>$\ln EXP$ | (5)<br>$\ln EXP$ | (6)<br>$\ln EXP$ |
|---|---|---|---|---|---|---|
| $lnGDP_i$ | 0.237*** | 0.237*** | 0.235*** | 0.239*** | 0.237*** | 0.233*** |
| | (0.0233) | (0.0233) | (0.0233) | (0.0233) | (0.0233) | (0.0233) |
| $lnGDP_j$ | 0.707*** | 0.706*** | 0.704*** | 0.707*** | 0.706*** | 0.710*** |
| | (0.0287) | (0.0287) | (0.0287) | (0.0287) | (0.0287) | (0.0287) |
| $lnPOP_i$ | -0.224 | -0.223 | -0.266 | -0.181 | -0.215 | -0.303* |
| | (0.167) | (0.167) | (0.167) | (0.167) | (0.167) | (0.167) |
| $lnPOP_j$ | 0.412** | 0.380** | 0.365** | 0.422** | 0.383** | 0.427** |
| | (0.182) | (0.182) | (0.182) | (0.182) | (0.182) | (0.182) |
| PTA Dummy (*I*) | 0.245*** | 0.252*** | | | | |
| | (0.0197) | (0.0199) | | | | |
| Importer Pref $(\overline{m})$ | | -0.350*** | | | | |
| | | (0.135) | | | | |
| $I - \overline{m}$ | | | 0.131 | | | |
| | | | (0.134) | | | |
| PAE | | | | 0.0630*** | 0.0629*** | |
| | | | | (0.00498) | (0.00498) | |
| RE | | | | -0.0202*** | | |
| | | | | (0.00627) | | |
| EE | | | | 0.151*** | | |
| | | | | (0.0400) | | |
| CE | | | | | -0.00392 | |
| | | | | | (0.00468) | |
| TE | | | | | | 0.0275*** |
| | | | | | | (0.00341) |
| Observations | 265,054 | 265,054 | 265,054 | 265,054 | 265,054 | 265,054 |
| Within R-Squared | 0.139 | 0.139 | 0.139 | 0.139 | 0.139 | 0.139 |
| F-Test | 41.52*** | 41.48*** | 41.33*** | 41.46*** | 41.48*** | 41.41*** |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10: Estimated Trade Volume changes

| | | Trade Volume effect % | |
|---|---|---|---|
| | Mean Total effect | High est.<br>(8.21%) | Low est.<br>(2.65%) |
| All Trade | 0.22657 | 1.88 | 0.60 |
| PTA Trade | 3.51194 | 33.42 | 9.76 |
| Non-PTA Trade | -0.36586 | -3.00 | -0.97 |

Note: the numbers in columns 3 and 4 are calculated as the mean total effect times the estimated trade cost reduction.

Figure 1A: Box Plot of Proportional Changes in All Trade Flows

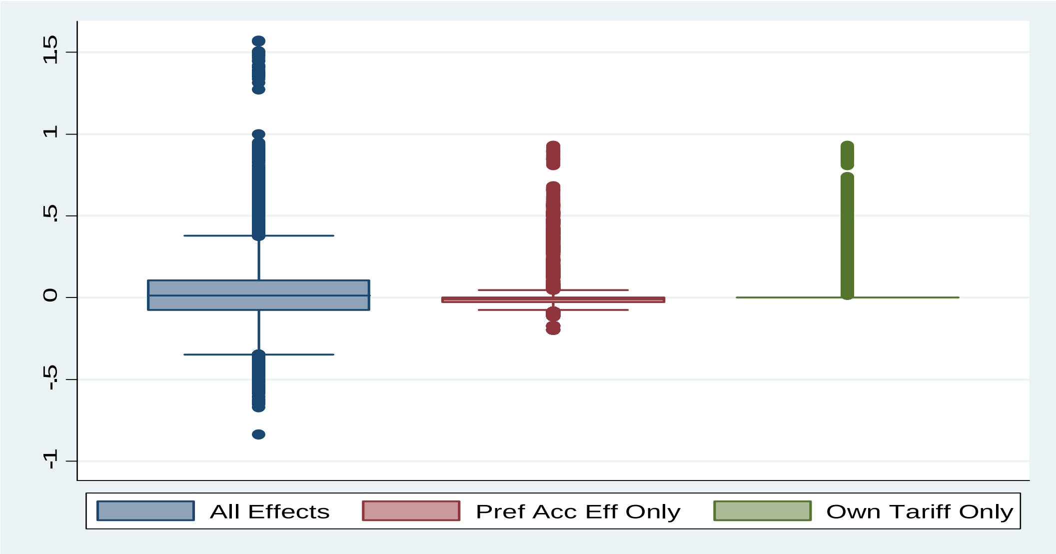


Figure 1B: Box Plot of Proportional Changes in Within-PTA Trade Flows

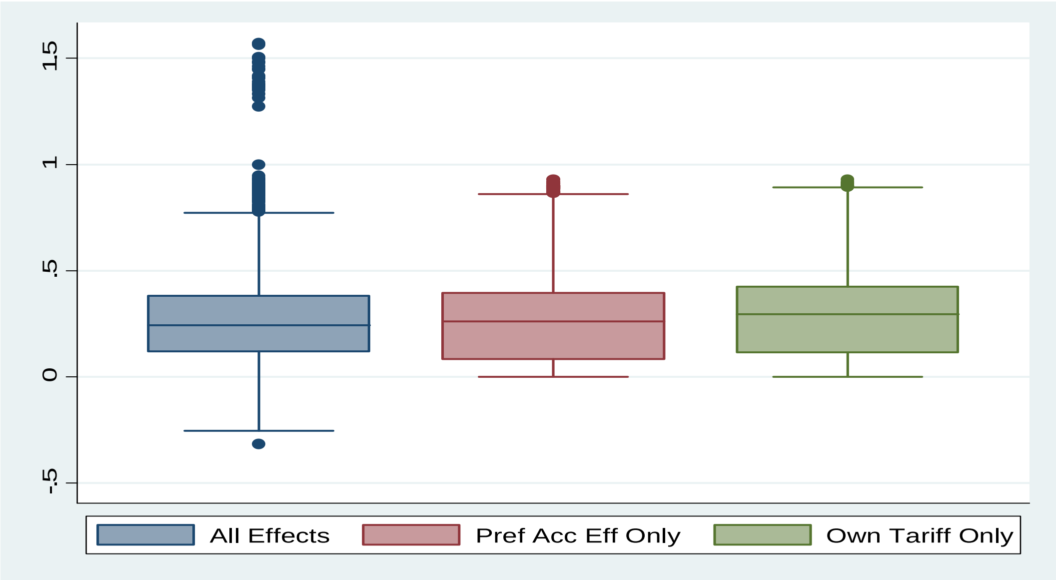


Figure 1C: Box Plot of Proportional Changes in Outside-PTA Trade Flows