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Pushan DUTT
Ilian MIHOV
Timothy VAN ZANDT
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(Revised version of 2011/47/EPS)

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Pushan Dutt*

Ilian Mihov**

Timothy Van Zandt***

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* Associate Professor of Economics at INSEAD, 1 Ayer Rajah Avenue, 138676 Singapore.
Email: Pushan.dutt@insead.edu

** Dean (Interim), Professor of Economics, The Novartis Chaired Professor of Management and Environment at INSEAD, 1 Ayer Rajah Avenue, 138676 Singapore.
Email: ilian.mihov@insead.edu

*** Professor of Economics, The Shell Fellow of Economic Transformation at INSEAD, Boulevard de Constance, 77305 Fontainebleau, France.
Email: timothy.van-zandt@insead.edu

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Pushan Dutt
INSEAD

Ilian Mihov
INSEAD and CEPR

Timothy Van Zandt
INSEAD and CEPR

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Abstract
We use 6-digit bilateral trade data to document the effect of WTO/GATT membership on the extensive and intensive product margins of trade. We construct gravity equations for the two product margins motivated by Chaney (2008). The empirical results show that standard gravity variables provide good explanatory power for bilateral trade on both margins. Importantly, we show that the impact of the WTO is concentrated almost exclusively on the extensive product margin of trade, i.e. trade in goods that were not previously traded. In our preferred specification, WTO membership increases the extensive margin of exports by 25%. At the same time, WTO membership has a negative impact on the intensive margin. Based on novel comparative statics results about how fixed and variable trade costs impact the product margins of trade, our results suggest that WTO membership works by reducing primarily the fixed rather than the variable costs of trade.

Keywords: Keywords: WTO, Gravity, extensive margin of trade, intensive margin of trade, trade costs.

1. Introduction

Since its inception in 1948, the General Agreement on Tariffs and Trade (GATT) has formulated and implemented the rules of world trade. The biggest overhaul of trading rules took place in the 1980s through the Uruguay Round of talks, and eventually led to the creation of the World Trade Organization in 1995. The agenda of the GATT/WTO has been to promote trade, reduce trade barriers through rounds of trade talks, and provide a venue for settling trade disputes.

However, its raison d'être as the promoter of world trade was cast in doubt by Rose (2004a), who found a negligible impact of WTO membership on the volume of bilateral trade flows. That paper spawned multiple follow-up attempts to validate or overturn Rose's surprising result. For instance, Subramanian and Wei (2007) show that the impact of GATT/WTO depends on what the country does with its membership, with whom it negotiates, and which products the negotiation covers.

E-mail: pushan.dutt@insead.edu (Dutt); ilian.mihov@insead.edu (Mihov);
timothy.van-zandt@insead.edu (Van Zandt)

Developing countries (e.g., India) enjoyed special exemptions in particular sectors (e.g., textiles) from the liberalization of trade; once these exceptions are accounted for, the WTO does promote trade. Tomz et al. (2007) argue that many countries are mistakenly classified as outside the GATT, even though they were de facto members with similar rights and obligations. They show that not counting such countries as GATT members systematically underestimates the effect of GATT on trade flows. Liu (2009) highlights the sample selection bias in the traditional gravity formulation: many country pairs exhibit zero trade, which the traditional formulation ignores by examining only strictly positive trade flows. Accounting for this, he finds a strong role for the WTO in initiating trade between non-trading countries—the so-called partner-level extensive margin of trade, as opposed to the partner-level intensive margin (increases in trade between partners that already trade with one another). Felbermayr and Kohler (2006) also emphasize the decomposition of the expansion of trade into partner-level extensive and intensive margins.[1] Helpman et al. (2008) argue that the puzzle is reconciled with an accurate theory-driven specification of the gravity equation. Using unidirectional trade data along with exporter and importer fixed effects reveals a statistically significant positive effect of WTO membership on trade volumes. Eicher and Henn (2011) argue the opposite—that accounting for multilateral trade resistance terms via time-varying exporter and importer fixed effects suffices to negate WTO trade effects.[2]

Even if we believe that the WTO raises trade volumes, there still remains the question of whether the effect of the WTO is through liberalization of trade policies. Rose (2004b) questions the importance of trade liberalization by showing that few, if any, measures of trade policy correlate significantly with WTO membership. Furthermore, he reports that trade liberalization lags WTO entry by many years and that membership imposes few trade policy changes amongst many members, especially among developing countries who remain closed to trade for years following GATT/WTO membership. In contrast, Bagwell and Staiger (2001) argue that GATT/WTO is not merely about tariff concessions and rules for tariff policies. Rather, "the central purpose of WTO rules is to create a negotiating forum where member governments can voluntarily exchange market access commitments, with the assurance that the property rights over negotiated market access commitments are secure against unilateral government infringement." In other words, GATT/WTO membership provides assurance of market access, that once foreign products enter a domestic market they will be accorded the same treatment as domestic products and most importantly, governments will not take policy actions to undermine the

1. Throughout this paper, the terms "extensive margin" and "intensive margin", when used without a qualifier, refer to the product-level margins.

2. They question the hierarchical coding of trade preferences in Subramanian and Wei (2007) that attributes all trade creation to preferential trading arrangements (PTA). That is, if a country pair are members of both a PTA and members of the WTO, the PTA dummy takes the value 1 while the WTO dummy takes the value 0.

promised market access. From this perspective, WTO membership creates certainty about market access and is more akin to a reduction in the fixed costs of trade.

Our paper attempts to clarify the role of the WTO by examining the effect of WTO membership on the extensive and intensive margins of trade. For the interpretation of our results, we turn to recent theory. A large number of trade models have emphasized the importance of firm-level productivity differences in trade patterns. These models arose out of empirical work showing striking firm-level differences in trading behavior. (See Bernard and Jensen 1995, 1999, 2004; Clerides et al. 1998; Aw et al. 2000; Eaton et al. 2004.) Incorporating such firm-level heterogeneity into trade models leads first of all to a decomposition of trade expansion into an increase in the average exports by firms that are already exporters (the firm-level intensive margin) and the number of exporters selling in the destination market (the firm-level extensive margin). When firms produce differentiated products, these firm-level margins translate into product-level margins, which are the subject of our empirical study.

Multiple theoretical papers have then analyzed the consequences of trade liberalization, in terms of reduction of fixed and variable costs of trade, on these margins (Eaton and Kortum 2002; Melitz 2003; Bernard et al. 2003; Chaney 2008). By examining the effect of WTO membership on these margins, we are able to evaluate whether the WTO works via a reduction in fixed costs or variable costs of trade. In order to link the predictions of these model to our empirical analysis, in an Appendix we set up variation of the model in Chaney (2008) that allows us to study its comparative statics more generally than under Chaney's assumption that productivities are Pareto distributed.

Not surprisingly, a reduction in either fixed or variable costs leads to more entry into a bilateral export market and thus increases the extensive margin. Thus, if there is any hope of distinguishing between reductions in fixed and variable costs, it must be through their effect on the intensive margin.

A reduction in *fixed* costs typically *reduces* the intensive margin: the increase in entry, without any change in prices, leads to a dilution of the market shares of the incumbent firms, and the average exports per firm is brought down even further by the fact that the entrants are less productive and sell less than the incumbents.[3]

Does then, a reduction in *variable* costs instead *increase* the intensive margin? Incumbent firms see their revenues rise, but there is entry by firms with lower productivities and hence lowers sales than the incumbents. When productivities and hence revenues follow a Pareto distribution, the average does not change: this is Lawless (2010)'s result that the intensive margin is unaffected by a changes in variable costs. We consider how this knife-edge result is likely to be perturbed for other distributions. For some plausible assumptions, such as a perturbation of the Pareto

3. This holds as long as the described mechanism is not undone by what is likely to be weak general equilibrium effect: the decrease in the fixed costs of the firms in the origin country increases their total profits; some of these profits could accrue to households in the destination country, with this extra income generating additional sales for each product sold there.

distribution that places an upper bound on firm productivity (that is, a lower bound on marginal costs), a drop in variable costs leads to an increase in the intensive margin. (Sun et al. (2011) conclude that the Pareto distribution with unbounded productivities is a poor fit for the distribution of Chinese firms.) Even more compellingly, this comparative statics arises if instead we introduce heterogeneity of fixed costs. For example, if lower-productivity firms have not only higher variable costs but also higher fixed costs, then again the intensive margin rises when variable costs fall.

In Section 2, as motivation we graph growth in trade in products that were already traded from 1962 to 1970 versus trade in newly traded products. This is a simple plot of time series. In Section 3, we perform two decompositions of the traditional gravity equation into an extensive and intensive product margin, which we use for our econometric analysis. The first, which is our baseline definition and which is linked to our theoretical model, decomposes the volume of bilateral exports into the number of products multiplied by average export per product (see Hillberry and Hummels 2008; Bernard et al. 2007). The second follows the methodology of Feenstra and Kee (2008). The Feenstra-Kee extensive margin of exports for a country pair measures the fraction of goods sold by the exporter in the destination but weighs each product by its importance in world exports to this destination, averaged over time. The Feenstra-Kee intensive margin is the market share of the exporter in the importer's total spending on the products the exporter sells there. The volume of bilateral exports equals the product of the two margins as a fraction of total imports in the destination country. Section 4 details the data sources and describes the other independent variables commonly used in the gravity equation specification. We use COMTRADE HS-6 data to decompose the total volume of trade into the extensive and intensive margins and examine how membership in the GATT/WTO influences these two margins of trade.

In Section 5, across gravity-based specifications for these margins, we show that the effect of WTO membership is mainly along the extensive product margin. In the most demanding specification (with time-varying importer and exporter fixed effects and country-pair effects) we find that the WTO raises the extensive margin by 25%. In contrast, regardless of the specification, WTO has a negative impact on the intensive margin of exports, reducing the intensive margin by 7%. This suggests that WTO membership works as a reduction of fixed rather than variable costs. We also find that the gravity specification is a good fit for explaining variations in the two margins, accounting for more than 75% of the variation in the margins in the most demanding specification. We perform a series of robustness checks to ensure that our main result is not too sensitive to reasonable variations in the specification. Importantly, we pay special attention to the zeros in the bilateral trade matrices, which if ignored will lead to biased results due to a sample selection bias and a heterogeneity bias, as emphasized by Helpman et al. (2008).

Our paper makes three contributions. First, it shows that the effect of WTO membership is mainly on the extensive margin and that it reduces the intensive margin, suggesting that it mainly represents a reduction in fixed rather than variable trade costs. Broda et al. (2006) show that the extensive margin and the rise in imports of new varieties is responsible for important increases in productivity growth. The WTO,

by facilitating such trade, has potentially large welfare effects. Second, our empirical results allows us to understand how well the theoretical predictions of the various new-new trade models are borne out in data that spans close to 100% of world trade. Finally, our decomposition allows us to evaluate how well the traditional gravity specification holds up in the data for the extensive and intensive margins.

2. A First Look

We start with some descriptive evidence by plotting the evolution of world trade over time and then decomposing the volume of trade into extensive and intensive margins, similar to the decomposition in Helpman et al. (2008). Helpman et al. (2008) show the decomposition for the extensive partner margin (the rise of trade between new partners) rather than the extensive product margin (the rise of trade in new products). To ensure that we have sufficient coverage over time and across countries, we use data from the World Trade Flows Database (Feenstra et al. 2005). This database contains information on bilateral exports for more than 150 countries over the period 1962–1999. The data are based on the 4-digit Standard International Trade Classification, revision 2, with 790 4-digit categories and accounts for 98 percent of all world trade.[4] Compared to more recent data from UNCTAD, these series are available only at a higher level of aggregation. While we revert to the more disaggregated data for our main empirical analysis, in this section, we use these series because they are available over a longer time frame, which helps is identify important trends in international trade.

Line 1 on Figure 1 shows the aggregate real volume of exports for the set of country pairs that had already positive exports prior to 1970. Line 2 shows the evolution of trade volume between these country pairs only in sectors where there was positive trade prior to 1970. We can think of this as the intensive margin of trade. The difference (plotted as line 3) shows the evolution of trade in sectors where there was zero trade at the beginning of the period within the set of countries that traded with each other prior to 1970.[5] Line 3 captures the evolution of the extensive margin of trade. Figure 1 strongly suggests that from the 1980s onwards, trade in sectors that these countries already had positive trade in 1970 remains relatively flat. At the same time, the growth in the overall trade volume is closely mirrored by the expansion of trade in new products. By 1999 more than half of the increase in trade was in goods that had not been traded in 1970.

4. Some trade gets classified at the 3-digit level but cannot be classified at the 4-digit level. We drop such trade. However, assigning it to fictitious sub-categories does not qualitatively affect our results.

5. In order to ensure that our results are not driven by the choice of initial year, we used the union of partners and sectors that had strictly positive trade at any time between 1962 and 1970.

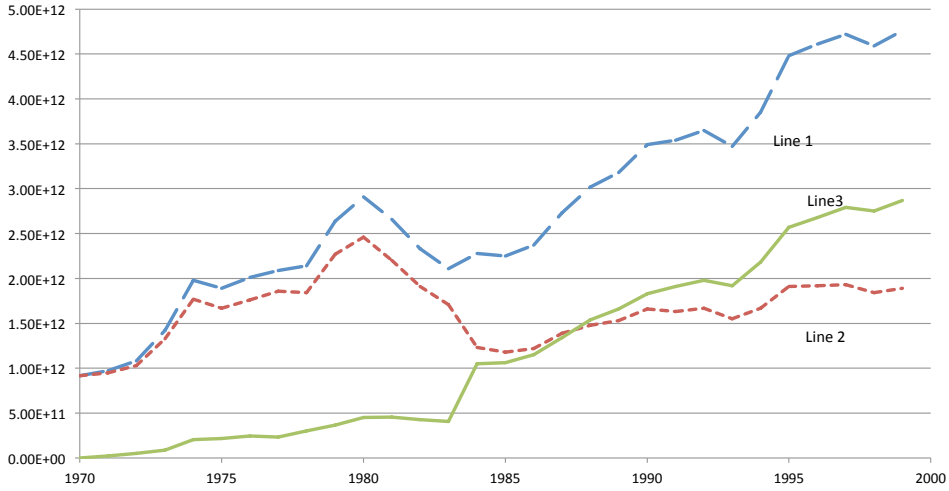

FIGURE 1. Intensive and extensive product margins from 1970 to 1999 for countries pairs that already traded in 1970. Line 1 (blue) shows total real exports. This is then divided between exports in sectors in which pairs already traded in 1970 (line 2, orange) and amounts in new sectors (line 3, green).

At a minimum, this figure suggests that the extensive margin has played a very important role in the overall expansion in trade volumes,[6] and could therefore be significantly affected by WTO membership.

3. Extensive and Intensive Margins of Bilateral Exports

3.1. Snapshot versus growth definitions of the margins

In most loose discourse about extensive and intensive product markets of trade, the extensive margin is referred to as growth in trade in newly traded goods whereas the intensive margin is growth in trade of already traded goods. In a static model, the "growth" is a comparative statics exercise. This is how Chaney (2008) decomposes his comparative statics of changes in total trade in response to changes in trade barriers.

However, in an empirical time-series exercise, these definitions of the extensive and intensive margins are problematic for two reasons. First, what is the moment in time that defines which goods are already traded? For our simple descriptive exercise in the preceding section, we loosely picked a time period. However, this does not

6. The World Trade Flows Database has a significant discontinuity in 1984 where there was a change in the product classification system. This is responsible for the sharp increase around 1984 shown by the extensive margin (line 3) in Figure 1. Even when we confine the sample period to 1984–1999, the importance of the extensive margin stands out.

work for an econometric exercise that examines how constantly-evolving independent variables drive trade flows. Second, there is natural churn of traded goods that would be present even if one otherwise fixed trade barriers and other bilateral determinants of trade. Change in technology and tastes leads some goods to disappear from trade flows and others to appear. In our descriptive exercise in the previous section, such hidden churn lowers the intensive margin and increases the extensive margin, compared to that generated solely by changes in barriers to trade.

Therefore, in empirical studies, these margins are defined not as growth terms but rather as snapshots, with the extensive margin being the number of goods traded (perhaps weighted) and hence capturing trade diversification, whereas the intensive margin is the average exports per product (perhaps weighted). These are the definitions that we adopt. In our baseline specification, we use unweighted measures, described in Section 3.2. As a robustness check, we also use the weighted measures of Hummels and Klenow (2005) and Feenstra and Kee (2008), described in Section 3.3.

3.2. Unweighted Measures

In our main specification, the extensive margin is a simple count of the number N_{od} of products exported from o to d and the intensive margin $\bar{x}_{od} = X_{od}/N_{od}$ is the average value of exports per product traded. Therefore, the overall volume of exports is the product of these margins:

$$X_{od} = N_{od} * \bar{x}_{od}.$$

We estimate separate gravity equations for these margins, with WTO membership as one of the independent variables. Since the gravity specification is always implemented in terms of the natural log of trade volumes, the sum of the logged margins will equal the log of the aggregate bilateral exports. Moreover, the sum of the estimated coefficients for the two margins of any independent variable will equal the coefficient on that variable in a standard gravity specification, with total bilateral exports as the dependent variable.

Theoretical underpinnings for our gravity equations for these margins come from a variant of Chaney (2008), which is a model of heterogeneous firms that participate in bilateral trade. Chaney (2008) studies the margins as a comparative statics exercise, but in Appendix A we derive the gravity equations for the extensive and intensive margins as defined here. These are also derived in a similar way in Lawless (2010). The gravity functional form arises when the productivities (hence firm sizes) are assumed to follow a Pareto distribution.

One motivation for estimating the WTO's impact on the extensive and intensive margins, rather than merely on total trade, is to disentangle whether entry into the WTO entails a reduction in fixed or variable trade costs. For this purpose, we study in Appendix B the comparative statics of reductions in trade costs in the model, but without the assumption of the Pareto distribution of productivities in Chaney (2008). This is an extension of Lawless (2010). A decrease in either the fixed or variable bilateral costs of trade leads to entry of new exporters, raising the extensive margin

of trade. However, fixed and variable trade costs can have opposite effects from each other on the intensive margin.

When fixed costs fall, the resulting entry reduces the intensive margin because it dilutes the market shares of incumbent firms and it brings into the market less efficient firms that have lower revenues. The effect of a reduction in variable trade barriers is more complicated. One the one hand, it raises the exports of existing exporters, which increases average exports per firm. On the other hand, it brings in less efficient firms. Their revenues will not be lower than the revenues of all the incumbent firms before the reduction in fixed costs, but they are still on the bottom of the distribution and they can bring the average revenue per firm down. These two effects cancel out when the firms' productivity has a Pareto distribution, and so the variable trade costs have no affect on average exports per product. However, for some natural perturbations to the Pareto distribution or else if the more productive firms have not only lower variable costs but also lower fixed costs, then the intensive market rises. In these plausible cases, changes in fixed and variable trade costs have opposite effects on the intensive margin. This allows us to distinguish between whether WTO members entails a reduction in primarily fixed trade costs or variable trade costs.

3.3. Weighted Measures (Feenstra–Kee)

As a robustness check, we consider also alternative definitions of the extensive and intensive margins from Hummels and Klenow (2005) and Feenstra and Kee (2008). Feenstra (1994) and Feenstra and Kee (2004) provide microfoundations for the construction of these indices.[7]

The difference between these measures and our previous ones is that products are given weights for each destination country d proportional to the total value of exports from all countries to d, with the weights being time invariant averages over the period of our sample. Let $J_{od,t}$ be the set of products exported by o to d in year t and let $J_{Wd} \equiv \cup_{o,t} J_{od,t}$ therefore be the set of all products exported to d from any country in any year in our sample. The index W stands for "world", i.e., the ensemble of origin countries. Define $\bar{X}_{Wd}(j)$ as the average value of exports from the world (summed over all exporting countries and averaged across years) of product j to d from the world. This is the weight given to product j for bilateral exports from any origin country o to d.

7. These papers develop a methodology for measuring the impact of new varieties on productivity. It uses a constant elasticity of substitution (CES) specification that identifies the gains from variety by keeping track of only two factors: the elasticity of substitution among different varieties of a good and shifts in expenditure shares among new, remaining, and disappearing goods. The main intuition is that increasing the number of varieties does not increase productivity much if new varieties are close substitutes to existing varieties or if the share of new varieties is small relative to existing ones. Broda and Weinstein (2006) use this methodology as well and apply it to all U.S. imports. They find that increased import variety contributes to a 1.2% per year fall in the "true" import price index.

Thus, the extensive margin of exports from county o to county d is

$$EM_{od,t} = \frac{\sum_{j \in J_{od,t}} \bar{X}_{Wd}(j)}{\sum_{j \in J_{Wd}} \bar{X}_{Wd}(j)}, \tag{1}$$

With our time-invariant weights, the measure of the bilateral extensive margin for a country pair changes over time due soley to changes in the set of goods sold by o in the destination d, $J_{od,t}$. The denominator is importer-specific and constant across exporting countries and time.

The intensive margin of exports from county o to d is

$$IM_{od,t} = \frac{\sum_{j \in J_{od,t}} X_{od,t}(j)}{\sum_{j \in J_{od,t}} \bar{X}_{Wd}(j)}, \tag{2}$$

where $X_{od,t}(j)$ is the value of exports from country o to country d of good j at time t. The intensive margin equals o's nominal exports relative to W's average exports in those categories in which o exports to d at time t ($J_{od,t}$). Thus, it measures the overall market share country o has within the set of categories in which it exports to d. Note that the product of the two margins is

$$EM_{od,t} * IM_{od,t} = \frac{\sum_{j \in J_{od,t}} X_{od,t}(j)}{\sum_{j \in J_{Wd}} \bar{X}_{Wd}(j)} = \frac{X_{od,t}}{\bar{X}_d},$$

which equals total bilateral exports from o to d in year t as a fraction of country d's average imports. This implies that adding the coefficients on the extensive and intensive margins will yield the traditional gravity coefficients once we include importer country fixed effects which would then exactly capture the term $\bar{X}_d$.[8]

4. Independent Variables

Market Access. To capture market access and the ability to circumvent artificial trade barriers, we use three measures of preferential market access: multilateral, bilateral, and unilateral. Trade liberalization under GATT/WTO is on a Most Favored Nation basis, whereby trade concessions granted to one member should be available to all members. Therefore, multilateral market access, the main focus of our paper, is captured by a dummy variable which takes the value 1 if both trading partners are members of the GATT/WTO and 0 otherwise. We also code a dummy that takes the value 1 if neither country in a country pair is a member of the WTO, with exactly one WTO member in a country pair as the omitted category. Data on dates of accession to the GATT/WTO are from the WTO website. Our data covers the

8. The correlation between the count measure and the Feenstra–Kee extensive margin measure equals 0.86 and correlation between exports per product measure and the Feenstra–Kee intensive margin measure equals 0.49.

period 1988–2006 and we find that 91 countries were already GATT/WTO members by 1988. 53 additional countries joined the WTO during the time period of our study (see Table C.1 in Appendix C for this list), whereas 45 countries remained outside the multilateral trading system up until 2006. This, in our view, provides sufficient variation in membership as well as changes in WTO membership over time.

Since the early days of GATT, there have been two major ways in which the non-discriminatory aspect has been violated. First, GATT permits exemptions to the MFN principle for regional or bilateral preferential trade arrangements that reduce local barriers to trade. Members in free trade areas and customs unions obtain privileged access to each other's markets that do not have to be granted to non-members. Such bilateral preferential trade arrangements are captured by a dummy variable which takes the value 1 if both trading partners are members in a preferential trade arrangement (PTA). Data on PTAs are also from the WTO website. PTAs account for 3% of our sample and 1634 of the 24,261 country pairs were part of a PTA for at least one year of the sample. The second major exemption to the multilateral principle is the Generalized System of Preferences (GSP). This is a scheme of trade preferences granted on a non-reciprocal basis by developed countries to developing countries. We follow Eicher and Henn (2011) and code a dummy variable as 1 if the importing county d grants a GSP to exporter o at time t.[9] GSP data are from Andrew Rose's website. 71 importing countries granted unilateral preferential access to at least one exporting country, whereas 124 exporters were beneficiaries under the GSP exception.

Gravity Variables. We use traditional gravity variables—such as geographic distance, contiguity, colonial links, and linguistic similarities—to capture factors that facilitate or impede trade. Geographic distance is measured as the logarithm of the distance (in kilometers) between the two most populous cities. Contiguity is a dummy variable that takes the value 1 if the country pair shares a common border. Linguistic similarity is captured using two variables: one is a dummy that equals one if the country pair shares a common official language; the other takes the value one if a common language is spoken by at least 9% of the population. Colonial links are measured using two variables, one that measures whether a country pair were ever in a colonial relationship (one country was the colonizer and the other colonized or vice versa) and one that captures whether a country pair had a common colonizer (for instance, Singapore and Malaysia). Our final measure of links between countries is a dummy that takes the value one if a country pair in the past had been part of the same country (example, Georgia and Russia). Data on these variables are obtained from the CEPII bilateral distance database (www.cepii.fr).

Table C.2 in Appendix C presents the summary statistics for measures of extensive and intensive margins as well as for other variables used in this paper. When all independent variables are included, our sample size has 231,501 country-pair–year

9. GSP resulted in a substantial increase in developing country exports. For empirical evidence, see Baldwin and Murray (1977), Romalis (2003), and Rose (2004a).

observations covering 24,594 country pairs, comprised of 190 exporters and 168 importers over the period 1988–2006.

4.1. Empirical Specification

Our benchmark specification of the gravity equations for the extensive and margins is the following:

$$\log N_{od,t} = \beta_{ext}^{both} WTO_{od,t}^{both} + \beta_{ext}^{none} WTO_{od,t}^{none} + \beta Z_{od,t} + \chi_{o,t} + \mu_{d,t} + e_{od,t} \quad (3)$$

$$\log \bar{x}_{od,t} = \beta_{int}^{both} WTO_{od,t}^{both} + \beta_{int}^{none} WTO_{od,t}^{none} + \beta Z_{od,t} + \chi_{o,t} + \mu_{d,t} + e_{od,t} \quad (4)$$

where $WTO_{od,t}^{both} = 1$ if both origin and destination are WTO members and 0 otherwise; $WTO_{od,t}^{none} = 1$ if both origin and destination are outside the WTO and 0 otherwise; $Z_{od,t}$ is a vector of traditional gravity variables including dummies for PTA and GSP; $\chi_{o,t}$ are exporter-year dummies; and $\mu_{d,t}$ are importer-year dummies.[10] Using such time-varying exporter and importer dummies dramatically reduces the scope for omitted variables, mis-measurement and even potential endogeneity in WTO membership. These dummies will not only capture global shifts in the patterns of world trade, but also changes in exports and imports of each country, some of which may be attributable to WTO membership.[11] At the same time, any changes in the HS-6 classification will also be subsumed in these dummies.

In a subset of specifications, we also add time-invariant country-pair dummies to account for all variation that is time-invariant but specific to bilateral pairs. Overall, the use of panel-data with both country-year and country-pair dummies allows us to account for selection of countries and country pairs into WTO and PTA membership, as emphasized by Baier and Bergstrand (2007). Finally, we use the Feenstra-Kee extensive and intensive margins as a robustness check.

From the definitions of the extensive and intensive margins, we can write overall bilateral trade as

$$\log X_{od,t} = \log N_{od,t} + \log \bar{x}_{od,t}. \quad (5)$$

Therefore, the sum of the estimated coefficients for the same variable in equations (3) and (4) gives the coefficient on the same variable in a standard gravity estimate with total bilateral trade as the dependent variable. For the Feenstra-Kee margins, the

10. Exporter and importer size are also subsumed within these country-year dummies.

11. In gravity model estimations, particular care has to be exercised in capturing the impact of the price indices, often addressed as multilateral trade resistance terms (Anderson and van Wincoop 2004; Baldwin and Taglioni 2006). The multilateral trade resistance terms reflect both the openness of the importing nation to all goods and the openness of the world to the exporter's goods (not simply the openness of a pair of exporter and importer). Trade between any pair of countries depends on their bilateral trade costs (including here transport and border costs) *relative* to average trade costs with all trade partners (measured by the multilateral trade resistance terms). Omission of these multilateral trade resistance terms biases estimates of the trade costs toward zero. The country-year dummies will capture these multilateral trade resistance terms.

decomposition is

$$\log X_{od,t} = \log EM_{od,t} + \log IM_{od,t} + \log \bar{X}_d \tag{6}$$

where the last term $\log \bar{X}_d$ will be absorbed in $\mu_{d,t}$, the time-varying importer dummies.

We also examine whether the effect of the WTO is increasing, decreasing, or roughly constant over time. We do so in two ways: First, we estimate the gravity models for the two models year by year, with exporter and importer dummies. While the year-by-year specification does not account for selection into WTO (see Baier and Bergstrand (2007), who make a case for using panel data to account for endogeneity of PTA membership,) it is a more general specification allowing us to estimate year-specific coefficients for every independent variable. Second, we use pooled data with country-year dummies, but we allow the coefficient on the WTO to be year-specific by interacting $WTO^{both}_{od,t}$ and $WTO^{none}_{od,t}$ with year dummies.

Recent papers by Evenett and Venables (2002), Anderson and van Wincoop (2004), Haveman and Hummels (2004), and Helpman et al. (2008) all highlight the prevalence of zero bilateral trade flows. This is a potential concern for our estimates, since the dataset that we use to calculate the various margins reports only positive levels of trade. For the aggregate bilateral trade data over the period 1988–2006, 37% of all possible bilateral trade flows show a zero value. For these country pairs, the extensive margin is clearly equal to zero but taking log of the extensive margin automatically drops these observations. Helpman et al. (2008) argue that this introduces two forms of bias: one is the standard sample selection bias and the second is a heterogeneity bias that arises from acknowledging that firms are heterogeneous and self-select into exporting. To examine whether this introduces a bias in our estimates, we follow Helpman et al. (2008) to correct for both types of bias.

5. Results

5.1. Baseline Estimates

The results from estimating gravity-specifications for the count measure of the extensive margin and the export per product measure of intensive margin of exports are reported in Table 1. Columns 1 and 2 use only time-varying exporter and importer fixed effects, while columns 3 and 4 add country-pair fixed effects. With country-pair effects, all time-invariant regressors are absorbed in these fixed effects. All standard errors are adjusted for clustering on country pairs.

In column 1 of Table 1, we see that the extensive margin of exports is significantly higher when both countries are WTO members. The estimated coefficient on *Both in WTO* dummy in column 1 implies that if both countries in a pair are members of the WTO, then the extensive margin of exports increases by 63.5%. Column 2 shows that WTO membership significantly reduces the intensive margin of exports by about 22.5%. Adding the two coefficients, we see that the WTO increases bilateral exports

TABLE 1. Gravity specification for the extensive and intensive margins.

	(1) extensive margin (count)	(2) intensive margin (exports per product)	(3) extensive margin (count)	(4) intensive margin (exports per product)
Both in GATT/WTO	0.492***	-0.255**	0.223***	-0.065**
	(0.092)	(0.104)	(0.015)	(0.027)
None in GATT/WTO	-0.134	0.319***	-0.040	-0.048
	(0.098)	(0.111)	(0.034)	(0.050)
Preferential trading arrangement	-0.147***	0.048	-0.004	0.297***
	(0.031)	(0.031)	(0.017)	(0.025)
GSP	0.329***	0.260***	0.078**	0.144
	(0.025)	(0.038)	(0.040)	(0.093)
Distance	-0.963***	-0.517***		
	(0.012)	(0.013)		
Contiguity	0.312***	0.065		
	(0.076)	(0.053)		
Common official language	0.428***	-0.019		
	(0.036)	(0.046)		
Common language spoken by at least 9% of population	0.116***	0.079*		
	(0.035)	(0.046)		
Colonial relationship	0.683***	0.402***		
	(0.065)	(0.059)		
Common colonizer	0.551***	0.445***		
	(0.030)	(0.039)		
Same country	0.508***	0.146*		
	(0.104)	(0.076)		
Observations	231501	231501	231501	231501
Number of pairs	24594	24594	24594	24594
R-squared	0.84	0.53	0.95	0.77
Joint significance test	33.74***	27.90***	20.77***	5.37***
Country-year effects	Yes	Yes	Yes	Yes
Pair effects	No	No	Yes	Yes

Standard errors (in parentheses) are adjusted for clustering on country pairs.
*Significant at 10%; **significant at 5%; ***significant at 1%.
All columns include a constant (not shown).

by approximately 26.7%. Adding country-pair fixed effects in columns 3 and 4, which accounts for all pair-specific time-invariant characteristics, leads to a similar finding: WTO membership increases the extensive margin while reducing the intensive margin (though the magnitude of its impact falls). When both members in a country pair become WTO members, they experience an increase in the extensive margin by 25% and a reduction in the intensive margin by 6.3%.

These results suggest that WTO membership acts more like a reduction in the fixed costs of trade—by reducing fixed costs it increases the number of products exported from origin to destination and by bringing in new smaller exporters, it reduces the intensive margin of exports.

In columns 3 and 4, the estimated coefficients for bilateral PTAs imply that country pairs who are members of a bilateral PTA tend to exhibit lower extensive margins and higher intensive margins, with an overall positive impact on bilateral exports. Columns

1 and 2 find a positive role for the Generalized System of Preferences, i.e. market access granted by rich countries to poor countries. GSPs are instrumental in raising both margins relative to countries that lack such market access. However, once we include country-pair effects, columns 3 and 4 show that GSP has an effect only on the extensive margin. This is in contrast to Rose (2004a), who shows that the Generalized System of Preferences plays a stronger role in trade flows.

Next, the traditional gravity variables have significant explanatory power for the two margins. Distance reduces both the extensive and intensive margin of exports, which is consistent with the role of distance as capturing variable trading costs. Having a common border raises the extensive margins but has no effect on the intensive margin. Linguistic similarity mainly impacts the extensive margin while colonial links positively influence both export margins. Finally, if a country pair was part of the same country, then these past ties tend to increase both margins. Overall, the traditional gravity variables affect the extensive margin of exports in much the same as it has been shown to affect bilateral trade flows.

5.2. Year-Specific Estimates of WTO Membership

In Table 2 we show how the effect of WTO membership on the two margins has evolved over time. We first estimate gravity specifications for the extensive and intensive margins year by year, where each specification includes a set of dummies for exporters and another for importers, as well as all pair-specific gravity variables shown in Table 1. Once again, such a specification should also account fully for the multilateral trade resistance terms.[12] Columns 1 and 2 in Table 2 report only the coefficient and significance of the dummy variable "Both in WTO". For 15 years of our sample, WTO membership has a positive effect on the extensive margin of exports. It has a negative or insignificant influence on the intensive margins of exports. Columns 3 and 4 use pooled data but estimate year-specific coefficients for the WTO dummies (both in WTO and neither in WTO) by interacting $WTO^{both}_{od,t}$ and $WTO^{none}_{od,t}$ with year dummies. We obtain coefficient estimates nearly identical in sign, magnitude, and significance as compared to columns 1 and 2; WTO membership again exhibits a strong positive effect on the extensive margin of exports.

Interestingly, the magnitude of the effect of the WTO on the extensive margin is the greatest just prior to the transition from the GATT to the WTO (1995). Subramanian and Wei (2007) present data showing that countries that joined prior to 1995 undertook fewer obligations to bind tariffs in the industrial sector, and bound tariffs at much higher levels in the industrial sector and in the agricultural sector as compared to those that joined after the 1995 transition from GATT to WTO. Since these countries did not have to undertake significant trade liberalization, WTO membership for them may be analogous to a reduction in the fixed costs of trade. Only for countries that joined

12. Note that Baier and Bergstrand (2007) argue that such cross-section estimates may fail to account for endogeneity and recommend the use of panel data.

TABLE 2. Year-specific effect of WTO on extensive and intensive margins.

Year	Coefficient on WTO: Year by Year		Coefficient on WTO: Pooled Data	
	extensive margin (count)	intensive margin (exports per product)	extensive margin (count)	intensive margin (exports per product)
1989	0.211	0.291	-0.024	0.297
1990	0.384	-0.219	0.197	-0.396
1991	1.125*	-0.421	0.920	-0.493
1992	0.986***	-1.281***	0.973***	-1.248***
1993	0.494**	-0.449	0.507**	-0.405
1994	0.911**	-0.867**	0.943***	-0.790**
1995	0.817***	-0.060	0.819***	-0.042
1996	0.334***	-0.279	0.341***	-0.258
1997	0.525***	-0.197	0.516***	-0.182
1998	0.479***	-0.346*	0.467***	-0.329
1999	0.308**	0.006	0.302**	0.006
2000	0.114	-0.238	0.114	-0.244
2001	0.878***	-0.366	0.885***	-0.361
2002	0.764***	-0.356	0.768***	-0.385
2003	0.732***	-0.263	0.738***	-0.261
2004	0.521**	-0.335	0.522**	-0.310
2005	0.385**	0.061	0.390**	0.093
2006	0.507**	-0.342	0.493**	-0.345

Standard errors (not shown) are adjusted for clustering on country pairs.

*Significant at 10%; **significant at 5%; ***significant at 1%.

The coefficient reported above is for the "Both in WTO" dummy. Each regression includes all controls. For the year by year estimate, we include exporter and importer dummies in each year; for pooled data we interact WTO membership dummies (both in WTO; none in WTO) with year dummies and include county-year fixed effects.

after 1995 did WTO membership entailed significant tariff concessions. For these countries, WTO membership seems more like a reduction in the variable costs of trade. If this is the case, then prior to 1995 we should observe WTO membership as having a positive impact on the extensive margin and a negative impact on the intensive margin. In contrast, post Uruguay-round the WTO may work via reduction in variable trade barriers, increasing the extensive margin but with an ambiguous or zero impact on the intensive margin. (If productivities have a Pareto distribution as in Chaney (2008), then a reduction in solely variable trade costs has no impact on the intensive margin; more generally, the net impact of a combined reduction in fixed and variable trade costs has an ambiguous impact on the intensive margin.) The results in Table 2 are somewhat consistent with such an expectation. First, we see a positive impact of WTO on the extensive margin for all years. Second, we observe a zero impact post-1995 on the intensive margin and a negative impact on the intensive margin in 1992 and 1994.

5.3. Selection and Heterogeneity Biases

A recent paper by Helpman et al. (2008) (HMR) criticizes the traditional gravity model on the grounds that it includes only those observations where we see strictly positive bilateral trade flows. Helpman et al. (2008) argue that excluding these zeroes, when we

take the log of the dependent variable, creates a sample selection bias from dropping zeros and a heterogeneity bias from omitting variables (unobserved trade costs) that account for firms' self-selection into exports. The first induces a downward bias in the estimates of trade costs (country pairs with large observed trade barriers that trade with each other are likely to have low unobserved trade barriers). Since trade barriers also affect the proportion of firms that select into exports, failure to account for this confounds the effects of trade barriers on trade with their effects on the proportion of exporting firms, inducing an upward bias in the estimated coefficient.

Consistent estimation of (5) requires controls for both the selection of country pairs into a trading relationship and the selection of firms into export markets. We adopt the two-step HMR methodology and estimate the following probit equation year by year

$$\rho_{od} = \Phi\left(\beta^{both} WTO_{od}^{both} + \beta^{none} WTO_{od,t}^{none} + \beta Z_{od} + \chi_o + \mu_d\right) \tag{7}$$

where ρ_{od} is the probability of positive exports from o to d, Φ is the cdf of the unit-normal distribution, χ_o and μ_d are exporter and importer fixed effects. Next, for each year t, we use the probit equation to predict two values: a latent variable z_{od} that determines self-selection into exports as $\hat{z}_{od}^{*} = \Phi^{-1}(\rho_{od})$; and the inverse Mills ratio

$$\hat{\eta}_{od}^{*} = \frac{\varphi(\hat{z}_{od}^{*})}{\Phi(\hat{z}_{od}^{*})},$$

where φ is the pdf of the unit normal.[13] In the second step, HMR claim that a transformation of gravity equation (5) that will give consistent estimates is

$$\begin{aligned}\log X_{od,t} = {} & \beta^{both} WTO_{od,t}^{both} + \beta^{none} WTO_{od,t}^{none} + \beta Z_{od,t} + \chi_{o,t} + \mu_{d,t} \\ & + \beta_{e\eta} \hat{\eta}_{od,t}^{*} + \beta_{z1} \hat{\tilde{z}}_{od,t}^{*} + \beta_{z2} \hat{\tilde{z}}_{od,t}^{*2} + \beta_{z3} \hat{\tilde{z}}_{od,t}^{*3} + e_{od,t},\end{aligned}$$

where $\hat{\tilde{z}}_{od,t}^{*} = \hat{z}_{od,t}^{*} + \hat{\eta}_{od,t}^{*}$ for each year t. The polynomial in $\hat{\tilde{z}}_{od,t}^{*}$ is an approximation of an arbitrary increasing function of the latent variable $z_{od,t}$, which in turn controls for firm-level heterogeneity; $\hat{\eta}_{od,t}^{*}$ is the Heckman correction for sample selection bias, again estimated year by year.

Helpman et al. (2008) suggests that trade barriers that affect fixed costs of exporting but not variable trade costs are valid exclusion restrictions and should affect only the probability of trade in equation (7). However, finding a valid exclusion restriction for the extensive margin is non-trivial since both fixed and variable costs affect the extensive margin. Therefore, we present results for the margins with and without an exclusion restriction. For the exclusion restrictions, we follow HMR and

13. HMR show that z_{od} is the ratio of the export profits of the most efficient firm to the common fixed export cost for exporters from o to d. Selection of firms into export markets is a monotonic function of this latent variable.

use their common religion index.[14] This index for a country pair (o, d) at time t is constructed as

$$\sum \left(\text{proportion of religion}_{ot}^{k}\right) * \left(\text{proportion of religion}_{dt}^{k}\right),$$

where k is an index for a particular religion.[15] In the absence of an exclusion restriction, we rely on identification from the nonlinearity of the inverse Mills ratio. To estimate (7) we use the IMF's Direction of Trade Statistics Database to code zero vs. positive exports between country pairs. We confirm that exports from o to d are indeed zero by cross-checking with the COMTRADE and the World Trade Flows Database (Feenstra et al. 2005).

The results with the HMR correction are shown in Table 3, which includes coefficient estimates for $\hat{\hat{\eta}}^{*}_{od,t}$ and for the polynomial in $\hat{\hat{z}}^{*}_{od,t}$ and time-varying exporter and importer fixed-effects. (Since some countries export to or import from all other countries in a particular year, fixed exporter and importer effects cannot be estimated in the probit equation, and all observations with that particular exporter or importer are dropped. As a result, the number of observations declines marginally from 231,501 in Table 1 to 206,798 in Table 3.) Columns 1 and 2 show the estimates for the two margins without any exclusion restriction; columns 3 and 4 use the common religion index as the exclusion restriction; while columns 5 and 6 add country-pair fixed effects to columns 3 and 4. Correcting for sample selection and heterogeneity bias, we see once again that common membership in the WTO increases the extensive margin and reduces the intensive margin of exports.

Comparing column 1 in Table 1 (without the HMR correction) to the one in Table 3 (with the HMR correction), we observe nearly a 50% decline in the coefficient on the WTO for the extensive margin. On the other hand, there is a marginal increase in the magnitude of the coefficient for the intensive margin. Similar to HMR, we find that the bias correction are dominated by the influence of unobserved firm heterogeneity rather than sample selection and that this is true only for the extensive margin but not for the intensive margin. In columns 1 and 2 where we do not use the exclusion restriction and we rely for identification on the non-linearity of the inverse Mills ratio, we get nearly identical results to those reported in columns 3 and 4 with the exclusion restriction. Comparing column 1 to column 3 and column 2 to column 4, we see that the coefficient and standard errors for all variables are nearly identical. Finally, when we add country-pair effects in columns 5 and 6, we see very similar result: WTO membership increases the extensive margin and reduces the intensive margin, and

14. HMR also use the fixed cost of starting a firm from the Doing Business database. However, data on these are available only from 2004 onwards. Therefore, we use only the common religion index as the exclusion restriction.

15. The set of religions we use are more comprehensive than that of Helpman et al. (2008). These include Bahais, Buddhist, Chinese Universist, Christianity, Confucian, Ethnoreligionist, Hinduism, Jainism, Judaism, Islam, Shinto, Sikhism, Taoists and Zoroastrian. The data are from Association of Religion Data Archives.

TABLE 3. Correction for sample selection bias and heterogeneity bias.

	(1)	(2)	(3)	(4)	(5)	(6)
	extensive margin (count)	intensive margin (exports per product)	extensive margin (count)	intensive margin (exports per product)	extensive margin (count)	intensive margin (exports per product)
Both in GATT/WTO	0.257***	-0.336***	0.251***	-0.342***	0.155***	-0.072***
	(0.096)	(0.125)	(0.095)	(0.125)	(0.015)	(0.028)
None in GATT/WTO	0.007	0.280**	0.004	0.279**	-0.006	-0.040
	(0.101)	(0.131)	(0.101)	(0.131)	(0.034)	(0.051)
Preferential trading arrangement	-0.159***	-0.114***	-0.179***	-0.132***	-0.029	0.247***
	(0.035)	(0.041)	(0.035)	(0.041)	(0.018)	(0.028)
GSP	-0.385***	-0.138***	-0.407***	-0.157***	-0.035	0.049
	(0.037)	(0.052)	(0.037)	(0.052)	(0.039)	(0.098)
Distance	-0.477***	-0.115***	-0.453***	-0.094**		
	(0.034)	(0.036)	(0.033)	(0.037)		
Contiguity	0.615***	0.121**	0.624***	0.129**		
	(0.063)	(0.057)	(0.063)	(0.057)		
Common official language	0.164***	-0.261***	0.154***	-0.270***		
	(0.039)	(0.052)	(0.039)	(0.051)		
Common language spoken by at least 9% of population	0.083**	0.075	0.080**	0.073		
	(0.035)	(0.049)	(0.035)	(0.049)		
Colonial relationship	0.618***	0.418***	0.615***	0.417***		
	(0.071)	(0.071)	(0.071)	(0.071)		
Common colonizer	0.323***	0.287***	0.308***	0.274***		
	(0.031)	(0.043)	(0.031)	(0.043)		
Same country	0.013	-0.079	-0.004	-0.093		
	(0.095)	(0.077)	(0.095)	(0.078)		
$\hat{\eta}$*	0.274***	-0.300***	0.242***	-0.327***	0.067**	-0.222***
	(0.053)	(0.064)	(0.053)	(0.064)	(0.030)	(0.054)
$\hat{z}$*	1.512***	1.346***	1.550***	1.384***	0.534***	0.022
	(0.068)	(0.083)	(0.067)	(0.084)	(0.036)	(0.062)
$\hat{z}^{*2}$	-0.092***	-0.193***	-0.093***	-0.195***	-0.066***	0.006
	(0.012)	(0.016)	(0.012)	(0.017)	(0.008)	(0.014)
$\hat{z}^{*3}$	-0.001	0.013***	-0.001	0.013***	0.003***	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	206798	206798	206798	206798	206798	206798
Number of pairs	23727	23727	23727	23727	23727	23727
R-squared	0.83	0.34	0.83	0.36	0.94	0.76
Joint significance test	51.74***	26.56***	51.80***	26.56***	21.23***	4.86***
Exclusion restriction	No	No	Yes	Yes	Yes	Yes
Country-year effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair effects	No	No	No	No	Yes	Yes

Standard errors (in parentheses) are adjusted for clustering on country pairs.
*Significant at 10%; **significant at 5%; ***significant at 1%.
All columns include a constant (not shown).

the bias correction results in a decline in the coefficient for the extensive margin as compared to the estimates in Table 1.

As in Table 1, we see that once we account for country-pair effects, PTAs have a positive influence on total trade, with the entire positive effect operating through an increase in the intensive margin while GSP has no impact on overall trade. The

inverse Mills ratio is significant at the 1%, so that the hypothesis of independence of the selection and regression equations is easily rejected. Finally, the polynomial in $\hat{\tilde{z}}^{*}_{od,t}$ are also statistically significant with signs similar to ones obtained in HMR, showing the importance of correcting for the heterogeneity bias.

5.4. Separating Out Effects of Trade Preferences

Subramanian and Wei (2007) argue that bilateral, unilateral, and multilateral preferences involve different degrees of liberalization; then defining them as we do in Table 1 contaminates the estimates. They recommend that WTO, PTA and GSP be defined mutually exclusively in order to be able to isolate the impact of each and identify what they dub "the pure WTO effect". However, as Eicher and Henn (2011) point out, Subramanian and Wei's hierarchical classification of dummies, with PTAs at the top and WTO at the bottom of the classification hierarchy, assumes that PTA membership represents the culmination of trade integration. They show that such a coding produces a WTO effect that is actually a PTA effect. Therefore, we use a different 7-fold classification to define trade preference dummies in a mutually exclusive and exhaustive fashion to identify a pure WTO effect. These are as follows.

1. Both countries of a country pair are WTO members but they do not belong to a PTA and the importer does not extend GSP to the exporter. This is the pure WTO effect.
2. Both are members of a common PTA, but at least one of them is not a member of the WTO and the importer does not extend GSP to the exporter. This is the pure PTA effect.
3. The importer extends GSP to the exporter but at least one of them is not a member of the WTO, nor do they belong to a common PTA. This is the pure GSP effect.
4. Both are members of the WTO, and at the same time, are members of a common PTA, but the importer does not extend GSP to the exporter.
5. Both are members of the WTO, the importer does not extend GSP to the exporter, but they do not belong to a common PTA.
6. Both are members of the WTO and are in a common PTA and the importer extends GSP to the exporter.
7. Both are members of a common PTA, the importer extends GSP to the exporter, and at least one country in the pair is not a WTO member.[16]

The results are reported in Table 4, where once again we show results for the two margins with exporter and importer country-year effects in columns 1 and 2 and with both country-year and country-pair effects in columns 3 and 4. Columns 1 and 2 also

16. Note that our classification is simply mutually exclusive and not hierarchical. For example, the Subramanian-Wei classification would use only three dummy variables: one for countries that are members of a PTA, one for countries where the importer grants a GSP but where the country pairs are not members of a PTA, and a third for where the countries are WTO members but not in a common PTA and where the importer does not extend GSP to the exporter.

TABLE 4. WTO, PTA & GSP defined mutually, exclusively, and exhaustively.

	(1) extensive margin (count)	(2) intensive margin (exports per product)	(3) extensive margin (count)	(4) intensive margin (exports per product)
1. Both in WTO + No PTA + No GSP	0.364***	0.045	0.238***	-0.044
	(0.039)	(0.048)	(0.017)	(0.029)
2. PTA + At least one not in WTO + No GSP	0.033	0.082	0.066	0.018
	(0.070)	(0.104)	(0.043)	(0.068)
3. GSP + At least one not in WTO + No PTA	0.193***	0.441***	0.147***	0.287***
	(0.041)	(0.076)	(0.046)	(0.102)
4. Both in WTO + PTA + No GSP	0.200***	0.113**	0.217***	0.304***
	(0.050)	(0.056)	(0.025)	(0.037)
5. Both in WTO + No PTA + GSP	0.717***	0.282***	0.273***	0.016
	(0.045)	(0.060)	(0.042)	(0.098)
6. Both in WTO + PTA + GSP	0.574***	0.071	0.290***	0.304**
	(0.081)	(0.090)	(0.051)	(0.122)
7. At least one not in WTO + PTA + GSP	0.185	0.871**	0.230***	0.245
	(0.120)	(0.393)	(0.069)	(0.265)
Observations	231501	231501	231501	231501
Number of pairs	24594	24594	24594	24594
R-squared	0.84	0.53	0.95	0.77
Joint significance test	34.06***	27.96***	20.79***	5.41***
Country-year effects	Yes	Yes	Yes	Yes
Country-pair effects	No	No	Yes	Yes

Standard errors (in parentheses) are adjusted for clustering on country pairs.
*Significant at 10%; **significant at 5%; ***significant at 1%.
Columns 1 and 2 include other gravity variables and all columns include a constant (not shown).

include the pair-specific gravity variables from Table 2 (not shown.) For the extensive margin, we observe a positive and significant coefficient whenever both countries in a pair are WTO members. More importantly, the coefficient in column 1 (or in column 3) on pure WTO effect implies that country pairs who grant each other only multilateral preferences exhibit a 44% (or 27% respectively for column 3) increase in the extensive margin of exports. The pure WTO effect on the intensive margin is negative once we include country-pair effects. The pure PTA effect on the two margins is insignificant while the pure GSP effect is positive on both margins of trade.

5.5. Feenstra-Kee Measure of Margins

Next, we replicate all the results with the Feenstra-Kee measure of extensive and intensive margins and present the gravity estimates for the decomposition based on equation (6). These results are shown in Table 5, where for brevity we report only the coefficient estimates for the "Both in WTO" dummy. Column 1 presents results with the extensive margin and column 2 with the intensive margin. As mentioned earlier, the sum of the coefficients is the coefficient on total bilateral exports since all specifications include county-year dummies, and this coefficient exactly matches the sum of the coefficient on the count measure and export per product measure. Row 1 is our baseline specification with exporter and importer country-year dummies; row 2

TABLE 5. Gravity specification for the Feenstra–Kee measures of margin.

	(1)	(2)
	Coefficient and standard error for extensive margin (Feenstra-Kee)	Coefficient and standard error for intensive margin (Feenstra-Kee)
Country-year effects	0.209*	0.027
	(0.114)	(0.108)
Country-year + country-pair effects	0.219***	-0.061**
	(0.025)	(0.028)
Correction for selection and heterogeneity bias[a]	0.140***	-0.058**
	(0.026)	(0.029)
Both in WTO + No PTA + No GSP[a]	0.239***	-0.045
	(0.027)	(0.029)

Standard errors (in parentheses) are adjusted for clustering on country pairs.
*Significant at 10%; **significant at 5%; ***significant at 1%.
a. Includes country-year and country-pair fixed effects.

adds country-pair fixed-effects; row 3 includes the HMR correction for heterogeneity bias and selection bias; row 4 reports the pure WTO effect from Table 4. Across specifications, we see effects very similar to the previous definition of margins—common WTO membership significantly increases the extensive margin of exports and significantly reduces the intensive margin of exports. In the most demanding specification, with country-year and country-pair effects and with the HMR bias corrections, we find that WTO membership increases the Feenstra-Kee extensive margin of exports by 15% but reduces the intensive margin by 5.6%.

5.6. Developed vs. Developing Country

Developed countries undertook far greater trade liberalization under the auspices of GATT reducing their average tariffs from 15% in 1947 to about 4.5% (Subramanian and Wei 2007). In contrast, developing countries had far fewer obligations to liberalize tariff barriers under the Special and Differentiated (S&D) treatment. Such an asymmetry implies that we should expect differential effects for GATT/WTO membership for developed vs. developing countries. For developed country importers, GATT/WTO membership should work by reducing the variable costs of trade, which should have a positive impact on the extensive margin of their exporting partners (in terms of product counts) and an ambiguous or zero impact on the intensive margin of exports (in terms of exports per product). For developing country importers, GATT/WTO membership may only be about reducing the fixed costs of trade. This should have a positive impact on the extensive margin and a negative impact on the intensive margin of their export partners. We examine this by estimating gravity specifications for the extensive and intensive margins separately for sub-samples of

TABLE 6. Developed vs. developing sub-samples.

	(1)	(2)	(3)	(4)
	Importer developed		*Importer developing*	
	extensive margin (count)	intensive margin (exports per product)	extensive margin (count)	intensive margin (exports per product)
Both in GATT/WTO	1.687***	0.253	0.311***	-0.264**
	(0.276)	(0.490)	(0.095)	(0.108)
None in GATT/WTO	-1.295***	0.242	-0.004	0.282**
	(0.315)	(0.528)	(0.101)	(0.115)
Preferential trading arrangement	-0.433***	-0.047	0.106***	0.111**
	(0.047)	(0.061)	(0.041)	(0.043)
GSP	0.167***	0.093	0.484***	0.171**
	(0.032)	(0.058)	(0.071)	(0.069)
Distance	-0.750***	-0.594***	-1.011***	-0.516***
	(0.025)	(0.035)	(0.013)	(0.014)
Contiguity	-0.509***	0.167	0.574***	0.019
	(0.152)	(0.102)	(0.072)	(0.062)
Common official language	0.137**	-0.122	0.546***	0.007
	(0.063)	(0.103)	(0.041)	(0.051)
Common language spoken by at least 9% of population	0.234***	0.178*	0.054	0.061
	(0.064)	(0.104)	(0.040)	(0.050)
Colonial relationship	0.671***	0.459***	0.842***	0.306***
	(0.068)	(0.087)	(0.112)	(0.065)
Common colonizer	0.046	-0.043	0.511***	0.429***
	(0.136)	(0.250)	(0.031)	(0.041)
Same country	0.265	-0.013	0.243**	0.096
	(0.328)	(0.178)	(0.107)	(0.081)
Observations	66112	66112	165389	165389
Number of pairs	4864	4864	19730	19730
R-squared	0.92	0.60	0.82	0.48
Joint significance test	35.37***	23.53***	26.95***	21.65***
Year effects	Yes	Yes	Yes	Yes
Country-year effects	Yes	Yes	Yes	Yes

Standard errors (in parentheses) are adjusted for clustering on country pairs.
*Significant at 10%; **significant at 5%; ***significant at 1%.
All columns include a constant.

developed and developing country importers. We use the Rose (2004a) categorization of countries into developed vs. developing.

These results are shown in Table 6 where all columns include country-year fixed effects. Columns 1 and 2 show the gravity estimates where the importer in a country pair is a developed country. We observe that WTO membership increases the extensive margin for their export partners and has an insignificant effect on the intensive margin, in line with the role of WTO membership reducing variable trade costs for these exporters in the destination country. Columns 3 and 4 show the estimates for the margins when the importing country is a developing country. Here we see that WTO membership increases the extensive margin and significantly reduces the intensive

margin. This in turn is consistent with conceiving WTO membership as reducing the fixed costs of trade.

5.7. Robustness[17]

We checked whether our results are not an artifact of the time frame and product classification used. To do this, we reran all our models using the World Trade Flows Database. While this database spans the time period 1962-1999, data are available only at the four digit level resulting in coarser measures of extensive and intensive margins. As with the COMTRADE data, we find that WTO membership has a positive and significant effect only on the extensive margin of trade.

Second, we evaluated whether the effect of the WTO was mainly due to multiple countries joining around the year of the switch from GATT to WTO. We did this by confining our sample to exporters who joined prior to 1994 or after 1996. Again, we find that the extensive margin is positively influenced by WTO membership. Similarly, when we confine our sample to importers who joined prior to 1994 or after 1996, the extensive margin of exports continues to be positively influenced by WTO membership. We also allowed the sample to vary across various GATT/WTO rounds. If we split the sample into pre-Uruguay round vs. post-Uruguay round, none of our results are qualitatively affected. As another sub-sample check, we dropped all the original members of GATT who signed the original GATT agreement in 1948. Again, this does not alter our conclusions regarding the importance of WTO membership for the extensive margin. In the final check, we evaluated if our results are simply driven by China's joining the WTO in the year 2001 (with other new members relatively unimportant in terms of their share in world trade). In both the overall sample which includes China and the sub-sample that excludes China, the coefficient on WTO membership is barely distinguishable in terms of magnitude and significance. Finally, we followed Tomz et al. (2007) and reclassified de facto members outside the WTO also as WTO members. This too does not alter our conclusions.

6. Discussion and Conclusion

Rose (2004a) highlights the WTO puzzle—that the biggest changes in international trade rules have failed to have an impact on the volume of trade between pairs of countries. Our paper decomposes the volume of trade into the extensive and intensive margin and shows that WTO membership has been instrumental in raising the extensive margin of trade while its impact on the intensive margin is negative. The positive impact on the extensive margin and the negative impact of the intensive margin are consistent with the role of the WTO as reducing the fixed rather than variable costs of trade. Our empirical results (with respect to the WTO) on the

17. All these results are available from the authors upon request.

extensive margin are in line with the standard Melitz/Chaney models of trade. The varying impact of WTO membership on the two margins holds across an array of permutations—accounting for the multilateral trade resistance terms and endogeneity of WTO and PTA membership via exporter and importer country-year effects and country-pair effects, for the prevalence of zeros in trade flows, and for various sub-samples and time periods. Unlike Rose (2004a), we do find that the overall impact of the WTO on total bilateral exports is positive and that it is the extensive margin channel through which WTO membership raises trade.

While the effect of WTO as reducing the fixed costs of trade is consistent with our results, there exists another intriguing possibility. Perhaps WTO is not at all about reducing trade barriers, variable or fixed. Rather it serves to resolve uncertainty in the mind of potential exporters regarding the evolution of international trade rules and they respond by exporting newer products into newer markets. This is the argument made most forcefully in Bagwell and Staiger (2001). The authors argue that GATT/WTO is not simply about market access through tariff reductions. Rather, WTO rules allow governments to credibly commit to market access and secure this access against unilateral policy interventions that undermine the link between market access and negotiated tariff reductions.[18] Handley and Limão (2010) use a dynamic, heterogeneous firms model to show how a reduction in trade policy uncertainty increases firm entry and trade. Empirically, they show that Portugal's accession to the European Community (EC) in 1986 reduced trade policy uncertainty and led to substantial investment and entry of Portuguese exporters into EC markets. Handley (2012) uses Australian data to show that multilateral policy commitments at the WTO reduce uncertainty and increase the extensive margin of exports. Our results that show that WTO accession increases the extensive margin of exports when we consider all participants in world trade, are in the same vein.

The impact of the WTO on the extensive margin and thus on export diversification also has important consequences on the role of WTO in economic development. Acemoglu and Zilibotti (1997) show that development goes hand in hand with diversification opportunities. Hausmann et al. (2012) show that the type of goods countries export matters—exporting goods associated with higher productivity levels leads to rapid economic growth grow more rapidly, after controlling for standard growth regressors such as initial income per head, human capital levels, etc. Broda et al. (2006) show that, across a wide sample of countries, the growth in the extensive margin of imports can also account for an important component of that country's productivity growth. The WTO by permitting diversification of trade can potentially play an important role in economic development.

18. The WTO's website emphasizes that one of the principle role of the WTO is to reduce uncertainty and increase predictability. It explicitly states: "The multilateral trading system is an attempt by governments to make the business environment stable and predictable."

Appendix A: Theoretical framework

A.1. Overview

Here we relate a version of the model in Chaney (2008) to help frame the interpretation of our empirical results. (We do not estimate the model structurally.) One goal is to provide an interpretation of the extensive and intensive margins, to link them to the gravity variables in our estimation, and, above all, to understand the comparative statics of these margins with respect to the fixed and variable trade costs that are affected by entry into the WTO. If our sole goal was to note that the intensive and extensive margins can be expressed as a gravity equation, we could simply write out the gravity equations in Chaney (2008). However, we provide an exposition of his model that develops as much of the model as possible without imposing the Pareto distribution on the productivities. This allows us to go beyond the Pareto distribution assumption in the comparative statics. that the reader can find in the cited papers.

Chaney (2008) is a model of trade with differentiated goods and imperfect competition, as introduced by Krugman (1980), and with heterogeneous firms as introduced by Melitz (2003). Compared to Melitz (2003), the main innovations are the introduction of heterogeneity across countries, heterogeneity across sectors of differentiated goods, and country-specific export decisions. His model has also a sector with a homogeneous good, to use as numeraire. These extensions allow Chaney (2008) to relate bilateral trade flows to bilateral country characteristics and trade costs and to the sector-specific elasticity of substitution. In addition, he assumes that firm productivities have a Pareto distribution, as in Helpman et al. (2004), which allows for closed-form solutions to the equilibrium.

Our model is first a simplification and then an extension of Chaney (2008). We simplify by considering only a single sector of differentiated goods. Each differentiated good is produced by a single firm operating in a single country. The good is sold domestically and might also be exported. The firm makes a decision of whether to produce at all and which markets to export to; each of these entry decisions incurs a fixed cost. The firm also sets the price of its good in each market in which it enters. The volume of sales in each market incurs a constant marginal cost that reflects both production and trade costs. The extension is that we develop the model as far as possible without the Pareto distribution.

This is a general equilibrium model of bilateral trade among N countries, $i = 1, \ldots, N$. However, we can focus on the trade flows to a single destination country d from all countries, including itself (domestic production); these origin countries are indexed by $o = 1, \ldots, N$. Our model of this market is *partial* equilibrium only because we take as given the income Y_i of each country; there are no other interactions between the bilateral flows into d and any other prices in the world trade.

The supply of labor in country i is denoted L_i. There is a homogeneous good, chosen as numeraire, which is produced at constant returns to scale, with 1 unit of labor yielding w_i units of the good. We assume it is produced in equilibrium in each country, and hence w_i is the wage in country i. The other source of income will be

profits of the firms selling differentiated goods. Following Chaney (2008), we assume that profits are distributed worldwide proportional to labor income. Let π be ratio of profits to labor income; then $Y_i = (1+\pi)w_i L_i$. The only general equilibrium effect is the determination of π, but in terms of the econometric equations that we derive, π is a variable to be estimated from the data and we do not need a functional form for its dependence on the country characteristics.

A.2. The destination market

In this section we consider a single destination market, without differentiating the goods and firms by country of origin. As a consequence, we can omit the indices d and o on variables.

Consider the consumption decisions of the representative agent in d. Let J be the set of differentiated goods sold there, endowed with some measure. Some of these goods are produced domestically and others are imported, as described above, but the agent views the differentiated goods symmetrically, independent of country of origin. Let q_j be the consumption of good $j \in J$ and let q_0 be the consumption of the homogeneous good. Then the representative agent's utility is $U(\cdot) = Q^{\mu} q_0^{1-\mu}$, where

$$Q = \left(\int_J q_j^{\hat{\varepsilon}/\varepsilon} dj \right)^{\varepsilon/\hat{\varepsilon}} \tag{A.1}$$

is a usual CES aggregate over the differentiated goods, with elasticity of substitution $\varepsilon > 1$ and $\hat{\varepsilon} = \varepsilon - 1$. (Integration is with respect to the measure on J.)

(Chaney (2008) has multiple sectors of differentiated goods, with a common elasticity of substitution within each sector and with a Cobb-Douglas aggregation across sectors. Since a fixed fraction of country income is spent on each sector, the equations and comparative statics we develop for a single sector are analogous to those for each sector in Chaney (2008).)

The CES function is homothetic, so the agent's problem is to chose proportions of the differentiated goods that minimize the per-unit cost P of Q and then choose the level of Q based on the Cobb-Douglas utility function. Let p_j be the price of good j. Then the minimum per-unit cost for Q is

$$P = \left(\int_{j \in J} p_j^{-\hat{\varepsilon}} dj \right)^{-1/\hat{\varepsilon}}. \tag{A.2}$$

The share of the expenditure on differentiated goods that goes to good j is $\left(p_j/P\right)^{-\hat{\varepsilon}}$, which means that demand for good j has constant elasticity ε. Then, given the Cobb-Douglas function over the aggregate Q and the homogeneous good q_0, he spends fraction μ of income on the differentiated goods.

Each differentiated good is produced by a single firm. We assume that the set of goods produced by any single firm has negligible mass, so that there is no cannibalization of demand by the firms' own goods. This means that the firms' pricing and entry decisions for its multiple goods are independent across goods. It is then

simpler to treat each good as if produced by a separate firm, so that j indexes both goods and firms.

Because demand for good j has constant elasticity, j's profit-maximizing price is a multiple $\varepsilon/\hat{\varepsilon}$ of its constant marginal cost c_j. (This price is independent of the prices of other goods; that is, the pricing has no strategic interaction.) It follows that firm j's profit is fraction $1/\varepsilon$ of its revenue x_j.

This revenue is calculated as follows. The destination country's income is Y, of which fraction μ is spent on differentiated goods, of which fraction $(p_j/P)^{-\hat{\varepsilon}}$ is spent on good j:

$$x_j = \left(\frac{P}{p_j}\right)^{\hat{\varepsilon}} \mu Y.$$

Since $p_\ell = (\varepsilon/\hat{\varepsilon})c_\ell$ for all $\ell \in J$,

$$P = \frac{\varepsilon}{\hat{\varepsilon}} \left(\int_{\ell \in J} c_\ell^{-\hat{\varepsilon}}\, d\ell\right)^{-1/\hat{\varepsilon}}, \tag{A.3}$$

and so

$$\left(\frac{P}{p_j}\right)^{\hat{\varepsilon}} = \frac{c_j^{-\hat{\varepsilon}}}{\int_{\ell \in J} c_\ell^{-\hat{\varepsilon}}\, d\ell}.$$

It is convenient to define $a_j = c_j^{-\hat{\varepsilon}}$ and $A = \int_{\ell \in J} a_\ell\, d\ell$; then $(P/p_j)^{\hat{\varepsilon}} = a_j/A$ and

$$x_j = \frac{a_j}{A} \mu Y. \tag{A.4}$$

The variable a_j is an inverse measure of j's marginal cost when selling in d, adjusted by the elasticity of demand in d. We refer to it as the *competitiveness* of firm j in market d, and A is then the aggregate competition in that market. Thus, total expenditure on differentiated goods in d is μY, and equation (A.4) says that j's fraction of this expenditure is the ratio of j's competitiveness to the aggregate competition of firms in the market.

Consider now the entry decisions. This is where there is strategic interaction between the firms. Although entry by firms has no effect on any other firm's pricing decision, it dilutes market share and therefore makes entry less profitable.

Let $\bar{J}$ be the set (measure space) of all *potential* firms. Firm j has a fixed entry cost F_j that drives the entry decision but does not affect the pricing decisions already analyzed. Given the entry decisions of all the other firms, i.e., given A, firm $j \in \bar{J}$ will want to be in the market if its profit $(1/\varepsilon)x_j$ exceeds its fixed cost F_j, i.e., if and only if

$$\frac{F_j}{a_j} \leq \frac{\mu Y}{\varepsilon A}.$$

Entry decisions J are an equilibrium if and only if this inequality holds for all $j \in J$ and the opposite inequality holds for all $j \in \bar{J} \setminus J$. An equilibrium in this type of congestion game always exists and here it is unique up to a set of firms of measure 0. Firms can be ranked by a composite cost index F_j/a_j that reflects both fixed and variable costs; in equilibrium, firms below a certain cost threshold enter and above that threshold do not.

A.3. Bilateral trade flows

We now introduce a parameterization of the populations of potential firms in different origin countries $o = 1, \ldots, N$, in order to identify bilateral trade flows from each origin country to the destination country d (including domestic production, whereby $o = d$). Let γ_o be the mass of firms in country o. We index firms in o by $k \in [0, 1]$, with a uniform distribution on this interval. That is, whereas in the previous section a typical firm that might export to d was denoted simply by j, here it is indexed by ok, where o is the country of origin and $k \in [0, 1]$ is the index of the firm within that country of origin.

The competitiveness of firm k in country o when exporting to d is $h_{od}(k)$. That is, for $j = ok$, $a_j = h_{od}(k)$. Assume that h_{od} is a continuous and decreasing function of k: lower-index firms are more competitive firms and thus higher-productivity firms. (Firms in o face the same labor cost and trade costs, and hence differences in margin cost are driven solely by differences in productivity.) We assume that the fixed cost of entry by a firm in o into the export market to d is the same for all firms in o; denote this cost by F_{od}. That is, for $j = ok$, $F_j = F_{od}$.

To distinguish between origin countries and the destination country, we now add the index d to various destination-specific variables from the previous section: ε_d, $\hat{\varepsilon}_d$, μ_d, A_d, Y_d. Furthermore, the revenue of firm j that exports to d was denoted x_j in the previous section, and here is $x_{od}(k)$ for $j = ok$.

Let κ_{od} be the threshold index for origin country o such that firms $k \leq \kappa_{od}$ in o export to d. Define $H_{od}(\kappa) = \int_0^{\kappa} h_{od}(k)\, dk$. Then the aggregate competition of country-o firms that export to d is $A_{od} = \gamma_o H_{od}(\kappa_{od})$ and the aggregate competition of all firms that export to d is $A_d = A_{1d} + \cdots + A_{Nd}$. Total nominal exports from o to d are

$$X_{od} = \gamma_o \int_0^{\kappa_{od}} x_{od}(k)\, dk = \frac{\gamma_o \int_0^{\kappa_{od}} h_{od}(k)\, dk}{A_d} \mu_d Y_d = \frac{A_{od}}{A_d} \mu_d Y_d. \qquad \text{(A.5)}$$

Following Eaton et al. (2004), Bernard et al. (2007), and Flam and Norstroöm (2007), we define the extensive margin as the number of products exported from o to d and the intensive margin as the average exports per product. In this model, each firm has a single product. (A multi-product firm can be treated as a collection of independent firms, one controlling each product, as long as the set of products has mass 0.) The extensive margin is thus the mass of firms that export:

$$EM_{od} = \gamma_o \kappa_{od}.$$

Assume an interior equilibrium in the sense that there is entry by some but not all firms from every origin country; then firm κ_{od} is indifferent between entering and staying out of the market, and so $F_{od} = (1/\varepsilon_d) x_{od}(\kappa_{od})$, or

$$F_{od} = \frac{1}{\varepsilon_d} \frac{h_{od}(\kappa_{od})}{A_d} \mu_d Y_d,$$

which implies that

$$\kappa_{od} = h_{od}^{-1}\left(\varepsilon_d F_{od}\frac{A_d}{\mu_d Y_d}\right). \tag{A.6}$$

The (nominal) intensive margin is the average export per product from o to d. This is total exports divided by the extensive margin:

$$IM_{od} = \frac{1}{\gamma_o \kappa_{od}}\frac{A_{od}}{A_d}\mu_d Y_d.$$

A.4. Gravity equations with the Pareto distribution

Here we derive from this model equations for bilateral trade and its decomposition into intensive and extensive margins, in terms of some of the usual gravity variables (particularly GDP) and with the power (log-linear) form of gravity equations. These are essentially the same gravity equations derived in Chaney (2008), with a few simplifications.

The still-opaque terms that could disrupt a gravity-type equation are κ_{od} and $H_{od}(\kappa_{od})$, both of which come from the form of h_{od}. The function h_{od} has a lot packed inside it. It reflects variation in the variable costs of firms in country o, the general level of such costs in country o, bilateral variable trade costs from o to d, and the elasticity of substitution in country d. We would like to pick apart these components, and end up with $\kappa_{od}(\cdot)$ and $H_{od}(\cdot)$ being power functions of their direct arguments and any implicit parameters.

This means that h_{od} should be a power function, but let's translate this into an assumption about our primitives: the costs of the firms. Let $c_{od}(k)$ be the marginal cost of firm k in country o when exporting to country d. This is the cost $c_{oo}(k)$ of supplying its domestic market times the iceberg trade costs τ_{od} from o to d. We assume that the distribution of costs for domestic production are the same across all countries, except for a scaling factor. This means that there is a function $c(k)$, common to all countries, and a constant c_o, such that $c_{oo}(k) = c_o c(k)$. We can choose $c(k)$ to have mean 1, so that c_o is the average marginal cost of the pool of potential firms in country o. The constant c_o is a reflection of the productivity in the differentiated goods sector compared to the productivity in the homogeneous goods sector. For example, if the real productivity in the differentiated goods sector is the same across all countries, then c_o is proportional to the cost w_o of labor. If instead, the cross-country productivity differences in the differentiated goods sector mirror these differences in the homogeneous goods sector, then c_o is the same in all countries.

To obtain the decreasing power function for h, we assume that $c(\cdot)$ is an increasing power function: $c(k) = (1/y)k^{y-1}$ for some $y > 1$. Then

$$h_{od}(k) = c_{od}(k)^{-\hat{\varepsilon}_d} = (\tau_{od} c_o (1/y) k^{y-1})^{-\hat{\varepsilon}_d} = \alpha_{od} h_d(k),$$

where $h_d(k) = (1/z_d)k^{z_d - 1}$, $z_d = 1 - \hat{\varepsilon}_d(y-1)$, and $\alpha_{od} = \tau_{od}^{-\hat{\varepsilon}_d} c_o^{-\hat{\varepsilon}_d} y^{\hat{\varepsilon}_d} z_d$. The variable α_{od} is the average competitiveness of potential firms in o when exporting to d, with the cross-country variations due to bilateral trade costs from o to d, the

average domestic costs within o, and the elasticity of substitution in d. It follows from $y > 1$ that $z_d < 1$. We assume also that $z_d > 0$, which constrains ε_d to not be too large, so that the average competitiveness is finite.

Thus, the competitiveness of potential firms in o that export to d has a Pareto distribution. Since firm size within that population is proportional to competitiveness, this functional form for the distribution of costs is backed up by the empirical regularity that firm size follows a Pareto distribution (power law).

Inverting, $h_{od}^{-1}(a) = (z_d/(\alpha_{od}a))^{1/(z_d-1)}$, and the threshold firm type for country o that exports to d is

$$\kappa_{od} = \left(\varepsilon_d z_d \frac{F_{od}}{\alpha_{od}} \frac{A_d}{\mu_d Y_d}\right)^{\frac{1}{z_d-1}}. \tag{A.7}$$

Furthermore,

$$H_{od}(\kappa_{od}) = \left(\varepsilon_d z_d \frac{F_{od}}{\alpha_{od}} \frac{A_d}{\mu_d Y_d}\right)^{\frac{z_d}{z_d-1}}$$

We assume further that the mass of potential firms is proportional to the labor income in a country. Since this is also proportional to total income given the way profits are distributed, there is γ such that $\gamma_o = \gamma Y_o$ for all o, with the caveat that γ depends on the endogenous determination of profits. Therefore, $A_{od} = \gamma Y_o H_{od}(\kappa_o)$ and we can calculate $A_d = A_{1d} + \cdots + A_{Nd}$ as

$$A_d = \left(\varepsilon_d z_d \frac{A_d}{\mu_d Y_d}\right)^{\frac{z_d}{z_d-1}} \gamma \sum_{o=1}^{N} Y_o \left(\frac{F_{od}}{\alpha_{od}}\right)^{\frac{z_d}{z_d-1}}.$$

Solving this equation for A_d yields

$$A_d = \left(\frac{\mu_d}{\varepsilon_d z_d}\right)^{z_d} (\gamma Y \Pi_d)^{1-z_d} Y_d^{z_d},$$

where Y is total world income and

$$\Pi_d = \sum_{o=1}^{N} \frac{Y_o}{Y} \alpha_{od}^{\frac{1}{1-z_d}} F_{od}^{\frac{-z_d}{1-z_d}}.$$

Π_d is a destination-specific measure of the competition in the destination market. It is a weighted average of inverse measures of bilateral variable and fixed trade costs for exporting to d and also for the destination country's costs of domestic production; it is higher for destination countries to which it is generally easier to export or that can better satisfy themselves internally. We may interpret it as an inverse measure of d's remoteness from the rest of the world or inverse of a multilateral trade-resistance index.

Substituting this equation for A_d into (A.7) and simplifying yields

$$\kappa_{od} = \frac{\mu_d}{\varepsilon_d z_d} \frac{1}{\gamma \Pi_d} \left(\frac{\alpha_{od}}{F_{od}}\right)^{\frac{1}{1-z_d}} \frac{Y_d}{Y}.$$

We can now write out the gravity equations for the bilateral extensive margin, intensive margin, and total trade.

$$EM_{od} = \frac{\mu_d}{\varepsilon_d z_d}\frac{1}{\Pi_d}\left(\frac{\alpha_{od}}{F_{od}}\right)^{\frac{1}{1-z_d}}\frac{Y_o Y_d}{Y},$$
$$IM_{od} = \varepsilon_d z_d F_{od},$$
$$X_{od} = \mu_d \Pi_d^{-1}\alpha_{od}^{\frac{1}{1-z_d}} F_{od}^{\frac{-z_d}{1-z_d}}\frac{Y_o Y_d}{Y}.$$

Appendix B: Comparative statics

B.1. Main idea

Our empirical study is on the effect that joining the WTO has on the bilateral intensive and extensive product margins. The story is that the WTO affects trade by reducing unobserved fixed and/or variable trade costs. From our results on the effect of WTO, we would like to back out, at least as a qualitative interpretation, whether WTO memberships brings mainly a reduction in fixed costs or mainly a reduction in variable costs. For this purpose, we want to understand what effect a reduction in these costs has on each margin of trade.

Consider the model in Sections A.1–A.3, that is, *without imposing the assumption that the c.d.f. of the marginal costs is a power function*. We address the comparative statics for a single origin–destination pair o and d: the affect on EM_{od} and IM_{od} when the o-to-d fixed or variable trade costs fall. Bilateral iceberg trade costs τ_{od} scale each firm's competitiveness by $\tau_{od}^{-\hat{\varepsilon}_d}$, so we write $h_{od}(k) = \tau_{od}^{-\hat{\varepsilon}_d}\hat{h}_{od}(k)$, where $\hat{h}_{od}$ is a function that remains fixed in this exercise and that captures the distribution of marginal costs for country-o firms in the destination market in the absence of variable trade costs. We can normalize the mass of firms in country o to be 1, so that the extensive margin is merely κ_{od}.

B.2. Extensive margin

Consider first the extensive margin. Intuitively, a drop in either fixed or variable costs for country o leads to entry by additional firms into market d. That is, the extensive margin rises. This is simple to see if we ignore equilibrium effects on A_d and Y_d. The equilibrium entry condition, (A.6), can be rewritten here as

$$\kappa_{od} = \hat{h}_{od}^{-1}\left(\varepsilon_d F_{od}\tau_{od}^{\hat{\varepsilon}_d}\frac{A_d}{\mu_d Y_d}\right), \tag{B.1}$$

Since $\hat{h}_{od}$ is a decreasing function, κ_{od} rises if either fixed trades costs F_{od} or variable trade costs τ_{od} go down, keeping A_d and Y_d fixed.

It is not difficult to obtain the same conclusion taking into account equilibrium effects on A_d and Y_d, giving us Proposition B.1

PROPOSITION B.1. *Let κ_1 and κ_2 be the equilibrium levels of entry given values F_1 and F_2 of the fixed costs and values τ_1 and τ_2 of the variable costs, such that $F_2\tau_2^{\hat{\varepsilon}_d} < F_1\tau_1^{\hat{\varepsilon}_d}$. Then $\kappa_2 > \kappa_1$.*

Proof. The values of A_d and Y_d are also endogenous; denote their corresponding values by A_1, A_2, Y_1, and Y_2. Since $\hat{h}$ is strictly decreasing, $\kappa_2 > \kappa_1$ if $A_2/Y_2 \leq A_1/Y_1$. Suppose instead that $A_2/Y_2 > A_1/Y_1$. We now assume $\kappa_2 \leq \kappa_1$ and derive a contradiction, namely that $A_2/Y_2 < A_1/Y_1$.

From equation (B.1) written for each origin country $i \neq o$, $A_2/Y_2 < A_1/Y_1$ implies that $\kappa_{i2} < \kappa_{i1}$. Thus, $A_2 < A_1$ from the definition of A_d. Furthermore, given that there is less entry by all firms in this market and hence lower expenditure on fixed costs and given that there is no perturbation to the parameters of the other markets except through the general equilibrium effect on worldwide profits, one can show that worldwide profits must rise. (This is easy to see when we ignore the general equilibrium effects. Profits of all firms operating in country d are fraction $1/(\varepsilon_d\mu_d)$ of Y_d—constant except for equilibrium effects on Y_d—minus the firms' fixed costs.) Therefore, $Y_2 > Y_1$ and hence $A_2/Y_2 < A_1/Y_1$. □

Thus, a mere increase in the extensive margin does not allow us to distinguish between a decrease in fixed costs or a decrease in variable costs.

B.3. Intensive margin: impact of a drop in fixed costs

Another fairly robust conclusion that does not depend on the Pareto distribution is that a decrease in F_{od} decreases IM_{od}. The lower F_{od} causes more entry by country-o firms. If a single one of these firms entered, it would have lower revenue than any of the other country-o firms already in the market because it has lower productivity. In addition, the additional market congestion from the firms that enter erodes the revenue of these firms and all other firms in the market. Both effects bring down IM_{od}.

However, there is a small countervailing general equilibrium effect: Keeping fixed the firms in the market, a reduction in their fixed costs increases their profit and hence worldwide income, including the income of the destination country. Again, keeping fixed entry decisions, the intensive margin is an increasing function of the d's income.

With the Pareto distribution and assuming an interior equilibrium (some but not all firms from each country enter), we have a straightforward result that this general equilibrium effect does not flip the comparative statics, since we derived the extensive margin as $IM_{od} = \varepsilon_d z_d F_{od}$, where ε_d and z_d are parameters. However, there are extreme cases in which it could dominate. Suppose, for example, that we start from an equilibrium in which all firms from o have entered market d. Then the decrease in fixed costs can have no impact on the number of firms in that market; only the impact on profits is present and so the intensive margin rises.

This example is extreme because it requires both that the destination country be large enough that profits generated there have a large impact on worldwide income and that entry into the market by country-o firms be very inelastic with respect to F_{od}.

We do not try to obtain general results, rather merely note what happens when we keep income fixed—e.g., when the country is small.

PROPOSITION B.2. *Consider a variant of the model in Sections A.1–A.3 in which country d income is not affected by profits generated by bilateral trade from o to d (a precise model can be obtained by having this income accrue to a country $N+1$ that has no labor and consumes only the homogeneous good). Then IM_{od} falls when F_{od} falls.*

B.4. Intensive margin: impact of a drop in variable costs

However, the impact of a decrease in *variable* trade costs from o to d on the intensive margin is ambiguous. On the one hand, it raises the revenue of all firms active in the market. On the other hand, it causes more entry by less productive firms. It is not that the new firms have lower revenue than what the existing firms had before the drop in variable costs. On the contrary, the revenue of the marginal firm κ_{od} is always $\varepsilon_d F_{od}$, as determined by the entry condition. However, there is a change in the overall distribution of revenues, with an ambiguous effect on the average revenue.

In the case of the Pareto distribution, these two effects exactly cancel each other. The intensive margin, equal to $\varepsilon_d z_d F_{od}$, is unaffected by changes in variable trade costs (recall that ε_d and z_d are exogenous parameters). The purpose of this section is to understand what is special about the Pareto distribution that leads to this knife-edge result and what happens if we perturb the assumptions.

We first derive a formula for the intensive margin that depends only on the exogenous parameters ε_d, F_{od}, and τ_{od} and the endogenous level of entry κ_{od}. This is possible because a zero-profit condition for the marginal firm pins down that firm's revenue, and the other firms' revenues depend on their competitiveness relative to the marginal firm. To simplify notation, we drop the o and d indices from most variables: $\varepsilon = \varepsilon_d$, $F = F_{od}$, $\kappa = \kappa_{od}$, all firms are country-o firms, and so on.

From the Grossman-Stiglitz model, we need only two properties. The first is that each firm's profit is fraction $1/\varepsilon$ of its revenue. The second is that the ratio of the revenues of two active firms k_1 and k_2 is

$$\frac{x(k_1)}{x(k_2)} = \frac{h(k_1)}{h(k_2)}.$$

Assume that κ is interior. Then the marginal firm has zero profit:

$$\frac{1}{\varepsilon} x(\kappa) = F.$$

The marginal firm's revenue is thus $x(\kappa) = \varepsilon F$ and each other active firm's revenue is

$$x(k) = \frac{h(k)}{h(\kappa)} \varepsilon F.$$

Therefore, the intensive margin is

$$IM = \varepsilon F \frac{1}{\kappa h(\kappa)} \int_0^{\kappa} h(k)\, dk.$$

Define $H(\kappa) = \int_0^{\kappa} h(k)\, dk$ and

$$\varphi(\kappa) = \frac{H(\kappa)}{\kappa h(\kappa)}.$$

With this notation,

$$IM(\kappa) = \varepsilon F \varphi(\kappa).$$

We have written IM and φ as functions of κ because we consider unspecified perturbations to the model that change the amount of entry (κ) but that do not change ε, F, or the function $h(\cdot)$ that determines the relative productivities. Then we can see that, whatever else has caused the change in entry, the intensive margin is a function only of the amount of entry. Our motivation is the effect of a reduction in variable costs, which we have already shown causes more entry, but we see that our conclusions apply to other factors that could generate more entry, such as an increase in the size of market d. Furthermore, we can see that we do not have worry about other general equilibrium changes to the entry of other firms or to income.

In our application, the entry is caused by a reduction in the bilateral marginal trade cost between the origin and destination country, which scales all the firms' marginal costs in the same way. In the Chaney model, IM is constant—such a change in entry has no impact on the intensive margin. We are interested in knowing the conditions under which, instead, a reduction in such trades costs makes the intensive margin rise. This is equivalent to conditions under which φ is increasing, and it depends solely on the shape of the function h or, equivalently, on the distribution of marginal costs.

We could look at conditions on h but equivalently we can look at conditions on H. This is useful because φ is the inverse of the elasticity of H:

$$\frac{1}{\varphi(k)} = \frac{k}{H(k)} h(k) = \frac{k}{H} \frac{dH}{dk}.$$

Denote this elasticity by $E(k)$. Then φ is increasing in k, and hence the intensive margin is increasing in κ, if and only if $E(k)$ is decreasing.

B.5. Some examples

We provide examples in which φ is constant, increasing, and decreasing.

B.5.1. Constant φ. φ is constant if and only if E is constant. A function has constant elasticity if and only if it is a power function: $H(k) = \beta k^z$. Then $h(k) = z\beta k^{z-1}$. Because h is strictly positive and weakly decreasing, $\beta > 0$ and $z \in (0, 1]$. The case of $z = 1$, where H is then a line, corresponds to free entry: $h(k) = \beta$ for all k. The case of $z \in (0, 1)$ corresponds to the Pareto distribution. Thus, we have replicated

Chaney's conclusion that the intensive margin is unaffected by variable trade costs (or other factors besides ε or F that might change the level of entry) when productivities follow a Pareto distribution.

We have noted that it also applies when there is free entry, though we do not need all this machinery for that conclusion. When there is free entry, every firm is a marginal firm and every firm earns zero profit. From the zero profit condition, every firm's revenue must be εF, and so the intensive margin is always εF. Of course, the decrease in costs means that each firm's price is lower and so real sales are higher: the real intensive margin rises when variable costs fall (this is a robust conclusion), but the nominal intensive margin is not affected.

Our analyses also shows that these are necessary conditions: the intensive margin is insensitive to the variable trade costs only if the distribution of marginal costs within the origin country is a power function or all firms have the same marginal cost.

B.5.2. Increasing φ. Suppose that the level of entry increases from κ_1 to κ_2. In both cases, firm revenue goes as low as εF. Firms of types $[0, \kappa_1]$ see their revenue increase from $(h(k)/h(\kappa_1))\varepsilon F$ to $(h(k)/h(\kappa_2))\varepsilon F$, and so the average revenue of these firms increases by a factor of $h(\kappa_1)/h(\kappa_2)$. However, there is entry by firms $[\kappa_1, \kappa_2]$ whose revenue are on the low end. If there are enough of these firms, then overall average revenue may not increase. On the other hand, if the elasticity of entry with respect to the variable costs is not too high, then the average revenue will increase.

As a first example of increasing revenue, suppose that $h(k) = 1 - k$. Then

$$H(\kappa) = \int_0^\kappa (1-k)\,dk = k - \frac{1}{2}k^2\Big|_{k=0}^{\kappa} = \kappa - \frac{1}{2}\kappa^2.$$

Thus

$$\varphi(\kappa) = \frac{1}{\kappa(1-\kappa)}\left(\kappa - \frac{1}{2}\kappa^2\right) = 1 + \frac{\kappa/2}{1-\kappa}.$$

It is increasing in κ.

We can also obtain increasing φ a small shift to the Pareto distribution that bounds the marginal costs from below and thus bounds firm size from above, which is quite realistic. Specifically, assume $h(k) = (1/z)(k+\eta)^{z-1}$, where $\eta > 0$ and $z \in (0,1)$. Then

$$H(\kappa) = \int_0^\kappa (1/z)(k+\eta)^{z-1}\,dk = (k+\eta)^z|_{k=0}^{\kappa} = \left((\kappa+\eta)^z - \eta^z\right).$$

Thus

$$\begin{aligned}\varphi(\kappa) &= \frac{z}{\kappa(\kappa+\eta)^{z-1}}\left((\kappa+\eta)^z - \eta^z\right)\\ &= z\frac{\kappa+\eta}{\kappa}\left(1 - \left(\frac{\eta}{\kappa+\eta}\right)^z\right)\end{aligned}$$

A numerical test shows that φ is increasing in κ for $\eta > 0$.

B.5.3. Decreasing φ. It is also easy to construct examples in which φ is increasing, by mixing heterogenous firms at the top with a pool of identical firms at the bottom. That is, h is initially decreasing but then is constant. H will initially be concave but then becomes a line. From the point where it becomes a line, the elasticity is increasing, and converges monotonically to 1.

B.6. Adding in heterogeneous fixed costs

These examples do not show a clear pattern of comparative statics. A more compelling adjustment to the Chaney (2008) model is to introduce heterogeneous fixed costs.

The simplest case is where the fixed cost also depends on k: denote it by $f(k)$ and assume that f is weakly increasing. Thus, low-productivity firms (higher k) have both weakly higher marginal costs and weakly higher fixed costs. This is a natural assumption. The distribution of the size of firms in the market, which depends on the distribution of their productivities, is unchanged by this extension. For example, if the marginal productivities follow a Pareto distribution, then so does the size of firms in the market.

The zero-profit condition for the marginal firm is $\varepsilon f(\kappa) = x(\kappa)$. Otherwise replicating the preceding analysis, we derive that the intensive margin is $\varepsilon f(\kappa)\varphi(\kappa)$. Therefore, if entry increases, for any reason except a change in ε or in the firms' fixed costs, the intensive margin goes up weakly if $f(\kappa)$ is weakly increasing and $\varphi(k)$ is weakly increasing, and it goes up strictly if, in addition, f or φ is strictly increasing.

The easiest case in which to understand this result is with identical marginal productivities. The marginal firm's revenue is $\varepsilon f(\kappa)$. But since each firm has the same revenue, the intensive margin is $\varepsilon f(\kappa)$, and is thus increasing in the level of entry.

In this setup, the fixed costs and marginal costs of the heterogeneous firms are exactly in line with each other. This is extreme, but it is natural that these two costs be positive correlated. However, consider instead that they are independent. Let's begin with a simple case in which fraction α_1 of the firms have fixed cost F_1 and fraction α_2 have fixed cost F_2, with $F_2 > F_1$. Within each of these populations, the distribution of productivities is the same. We can index firms within population j by $k_j \in [0, 1]$ and let $a(k_j)$ be the productivity of firm k_j in that population. Let IM_j be the intensive margin within population j. The mass of firms with fixed cost F_j in the market is $\alpha_j \kappa_j$, and so the overall intensive margin is the weighted average of IM_1 and IM_2:

$$\frac{\alpha_1\kappa_1}{\alpha_1\kappa_1 + \alpha_2\kappa_2} IM_1 + \frac{\alpha_2\kappa_2}{\alpha_1\kappa_1 + \alpha_2\kappa_2} IM_2.$$

Now assume that the within-populations intensive margins are constant, i.e., that φ is constant. This means that the marginal productivities within each population either have a Pareto distribution or are identical.

Consider first the case where both κ_1 and κ_2 are interior. Then $IM_j = \varepsilon F_j \Phi$, where Φ is the constant value of $\varphi(\cdot)$. The intensive margin is therefore proportional to

$$\frac{\alpha_1\kappa_1}{\alpha_1\kappa_1 + \alpha_2\kappa_2} F_1 + \frac{\alpha_2\kappa_2}{\alpha_1\kappa_1 + \alpha_2\kappa_2} F_2.$$

This is increasing if and only if the proportion of firms with fixed cost F_2 increases as there is more entry, that is, if and only if

$$\frac{\kappa_2}{\kappa_1}$$

is increasing.

We need to invoke the fact that κ_2 and κ_1 are linked to each other. Each firm's revenue depends only on its marginal cost. Thus, $x(\kappa_2)/x(\kappa_1) = h(\kappa_2)/h(\kappa_1)$; since also $x(\kappa_2)/x(\kappa_1) = F_2/F_1$, we have

$$\frac{h(\kappa_2)}{h(\kappa_1)} = \frac{F_2}{F_1},$$

implying that $h(\kappa_2)/h(\kappa_1)$ remains constant.

Here we have the Pareto distribution, and so

$$\frac{h(\kappa_2)}{h(\kappa_1)} = \left(\frac{\kappa_2}{\kappa_1}\right)^z$$

Since $h(\kappa_2)/h(\kappa_1)$ is constant, so is κ_2/κ_1. Thus, we have that the intensive margin is constant as there is more entry.

However, with enough entry, κ_1 maxes out at 1 while κ_2 is still interior. This has two effects. Now unambiguously κ_2/κ_1 is increasing as there is more entry. In addition, IM_1 increases because entry of additional firms does not dilute the average revenue of the firms in population 1. With IM_1 increasing (but always less than IM_2) and with the weight shifting toward IM_2, the overall intensive margin increases.

We can now extend this to a continuum of fixed costs, whose distribution is independent of the distribution of productivities. Within the population of fixed costs for which the marginal firms are interior, the intensive margin is constant as there is more entry. Within the popululation of fixed costs for which all firms have entered, the intensive margin is increasing when there is more entry, but it always remains lower than the intensive margin for the fixed costs for which entry is partial. Overall, the intensive margin rises, both because of the increasing intensive margin for firms with lower fixed costs for which entry is complete, and because higher fixed cost firms, which have higher intensive margins, gain share in the population of firms that have entered.

B.7. Multilateral changes in trade costs

Entry by destination country d into the WTO could reduce fixed or variable trade costs of all countries when exporting to d. We have only considered the comparative statics with respect to a bilateral change in trade costs. However, our results hold up for such multilateral reduction in trade costs, with a caveat.

Suppose trade costs fall for all countries that export to d. For country o, there are two countervailing effects on its extensive margin EM_{od}: the reduction of its own trade

costs cause more firms to enter; the entry by more firms from other origin countries creates market congestion that deters entry by county-o firms.

Collectively, there must be more aggregate competition in market d. With symmetry between the origin countries, there must there be an increase in each country's extensive margin of trade with d. However, there could be highly symmetric cases in there is so much entry by firms from some countries that entry by firms from some other origin country is lower. Otherwise, the comparative statics derived above for the impact of a reduction in the bilateral trade costs for exporter o to destination d on that origin countries intensive and extensive margins hold also when all exporters trade costs fall.

Appendix C: Additional Tables

TABLE C.1. Countries that joined the WTO After 1988 (the first year of our sample).

Country	Year of WTO Accession	Country	Year of WTO Accession
Albania	2000	Lesotho	1988
Angola	1994	Lithuania	2001
Armenia	2003	Macao, China	1991
Bahrain	1993	Macedonia	2003
Bolivia	1990	Mali	1993
Brunei	1993	Moldova	2001
Bulgaria	1996	Mongolia	1997
Cambodia	2004	Mozambique	1992
China	2001	Namibia	1992
Costa Rica	1990	Nepal	2004
Croatia	2000	Oman	2000
Czech Republic	1993	Panama	1997
Djibouti	1994	Papua New Guinea	1994
Dominica	1993	Paraguay	1994
Ecuador	1996	Qatar	1994
El Salvador	1991	Saudi Arabia	2005
Estonia	1999	Slovak Republic	1993
Fiji	1993	Slovenia	1994
Georgia	2000	Solomon Islands	1994
Grenada	1994	St. Kitts and Nevis	1994
Guatemala	1991	St. Lucia	1993
Guinea	1994	St. Vincent and the Grenadines	1993
Guinea-Bissau	1994	Swaziland	1993
Honduras	1994	Tunisia	1990
Jordan	2000	United Arab Emirates	1994
Kyrgyz Republic	1998	Venezuela	1990
Latvia	1999		

TABLE C.2. Summary statistics.

Variable	*No. of obsv.*	*Mean*	*Std. Dev.*
Extensive margin (count)	231501	3.431	2.335
Intensive margin (exports per product)	231501	11.130	2.277
Feenstra-Kee extensive margin	231501	-4.121	2.616
Feenstra-Kee intensive margin	231501	-4.970	2.219
Both in GATT/WTO	231501	0.671	0.470
None in GATT/WTO	231501	0.027	0.163
Preferential trading arrangement	231501	0.062	0.242
GSP	231501	0.120	0.325
Distance (log)	231501	8.625	0.852
Contiguity	231501	0.025	0.156
Common official language	231501	0.151	0.358
Common language spoken by at least 9% of population	231501	0.156	0.363
Colonial relationship	231501	0.019	0.137
Common colonizer	231501	0.085	0.278
Same country	231501	0.012	0.110
Common religion	453996	0.373	0.323

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Europe Campus
Boulevard de Constance
77305 Fontainebleau Cedex, France
Tel: +33 (0)1 60 72 40 00
Fax: +33 (0)1 60 74 55 00/01

Asia Campus
1 Ayer Rajah Avenue, Singapore 138676
Tel: +65 67 99 53 88
Fax: +65 67 99 53 99

Abu Dhabi Campus
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