Latent Exports: Almost Ideal Gravity and Zeros*

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Abstract

Almost Ideal gravity associates zero trade flows with variable and fixed trade cost variation in a flexible demand system. Latent trade shares between non-partners are inferred from the Tobit estimator applied to trade among 75 countries and 25 sectors in 2006. Latent Trade Bias (LTB) is the difference between the latent trade share and the as-if-frictionless trade share. Explained LTB variance decomposition shows 52% due to variation of variable trade cost, 24% due to non-homothetic income effects, and 24% due to fixed trade cost effects. Counterfactual variable (fixed) cost reductions suggest cases of successful export promotion between non-partners.

Keywords: Zero flows; variable cost; fixed cost; latent trade.
JEL Codes: F10, F13, F14.

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1 Introduction

Action on the extensive margin (entry or exit) of bilateral trade accounts for a large portion of the variation of trade in cross-section or time series.[1] The standard Constant Elasticity of Substitution (CES) gravity model loads the explanation of zeros onto fixed export costs because standard iceberg unit costs must rise without bound to drive trade to zero. In contrast, economic intuition suggests that choke price exceeded by high per-unit trade cost may be an important alternative explanation for zeros. Choke price variation is intuitively likely to be large – demand elasticities with respect to price vary across source countries and bilateral trade costs vary across destinations. Income effects may differ across destination countries, as variations in income per capita interact with income elasticities that differ from one. An Almost Ideal (Demand System) gravity model is developed in this paper to explain zeros by a combination of choke price variation and fixed export costs. Choke price variation is further due to variable costs and their interaction with varying demand elasticities and variation of income elasticities interacting with variation of per capita incomes. Variance decomposition reveals that variable cost variation accounts in the estimated model for a much higher proportion of zeros than does fixed cost variation or income elasticities variation.

The estimated model is applied to illustrate its potential for evaluating export promotion on the extensive margin. Export promotion motivates national policy, both unilateral and in trade negotiations, while firms search for profitable new destination markets. Quantification of the various causes of zeros is needed to guide export promotion on the extensive margin. Some types of export promotion policies are permissible under WTO rules, basically affecting fixed costs via providing information, facilitating links, helping with licensing and regulation requirements, and negotiating bilateral fair treatment in the application of regulations. Exporter countries could target export promotion more effectively if they knew which cost was more important. Commercial attachés to embassies and consulates in each destination could allocate time between intensive and extensive margin export trade accordingly. Exporting firms could target entry markets more effectively with a sense of which of the zeros were viable for given cost advantages.

A gravity model based on Almost Ideal Demand System (AIDS) preferences and heterogeneous firms has a closed-form suitable for estimation.[2] The version developed in

[1] Baldwin and Harrigan (2011) report the incidence of zeros in U.S. trade in 2005 is over 90 percent in imports of nearly 17,000 HS10 categories from 228 countries. Time series action on the extensive margin is documented by Besedes and Prusa (2006). The time a country is "in" a market is often fleeting and about 30% of trade relationships experience "flipping' on and off.

[2] We interpret gravity as in Anderson (2011) – a model of the distribution of given supplies across multiple destinations.

this paper is flexible enough to allow heterogeneous price, fixed cost, and income elasticities to interact with a combination of fixed costs and iceberg costs in determining trade flows both positive and latent. We extend the Feenstra (2010) version of AIDS to allow exporter-specific substitution parameters, and exporter-specific non-homothetic income effects on the reservation prices associated with latent trade.

Latent trade is defined (in Section 5.1) as the hypothetical stock required to make the agent indifferent between consuming it and selling a marginal unit after absorbing the fixed trade cost. Trade Bias, in the literature, is the difference between predicted trade and as-if-frictionless trade. Latent Trade Bias (LTB), as used in this paper, is the difference between the latent trade share (the absolute value of a negative number for cross-border trade) and the as-if-frictionless trade share – a Trade Bias concept applicable to both latent and positive trade (see Figure 3 in Section 5.1 for details).

The Tobit estimator of AI gravity predicts the latent value of bilateral trade shares for non-partners, given the inferred bilateral iceberg costs and entry costs as well as the demand parameters. The estimated sectoral AI gravity model implies that, on average, variable cost explains 52% of the variation in LTBs, while fixed cost explains 24%. The remaining 24% is explained by income effects on demand due to the variations in per capita income interacting with variation in origin-specific income elasticities. Variable cost dominates fixed cost and income effects for almost all sectors. The variation in the causes of zeros implies differences in the efficacy of export promotion policies on the extensive margin.

AI gravity is estimated using the bilateral manufacturing trade and production data among 75 countries and 25 sectors in 2006. The three-digit sectoral aggregation allows us to match trade with production data in order to estimate a full (internal trade inclusive) gravity model. Our version of AIDS in principle allows 75 price, fixed-cost, and income elasticity parameters (origin-specific). To reduce the parameter dimension in estimation, our estimator projects the price elasticity parameter for each exporter as a linear function of exporter income. Intuitively, goods produced by rich countries are less likely to be substituted for, and thus are price-inelastic. The estimation results show that bilateral distance reduces trade by less for richer exporters, implying significant distance (price) elasticity heterogeneity across exporters. Price elasticity heterogeneity also varies significantly across sectors.

Counterfactual experiments in export promotion assess the relative importance of variable and fixed costs in preventing trade from occurring. Cost reductions can shift the delivered price below the price associated with the break-even quantity. An extreme counterfactual eliminates either variable or fixed cost. On average, the elimination of bilateral variable cost decreases the number of current sectoral zero flows much more than does the elimination of bilateral fixed cost. These are the upper bounds for what the hypothetical export promotion policy could do. More relevant to export promotion targeting, a 10% cut in variable cost induces trade in a much larger number of potential bilateral pairs than does a 10% cut in fixed cost. Here, the three-digit ISIC level of the data presumably hides a much larger number of potential targets in more disaggregated sectors.

An alternative clue to export promotion from our application is that reducing variable cost improves the probability of a new trading partner more if the source country is poorer. The results are consistent with the intuition that products from poorer countries are more price-elastic and thus are more likely to induce trade to occur when variable trade costs decrease. Similarly, reducing export fixed costs (e.g., regulation cost) improves the probability asymmetrically across exporters with different incomes. Moreover, The marginal effect of reducing fixed cost on switching zero trade to positive is smaller than reducing variable cost.

A headline example is Ethiopia's export trade in leather goods in 2006. The application suggests that a 10% cut in pair-specific fixed entry cost would open 21 export markets. A 10% cut in variable cost would open 39 export markets. In both cases, the new destination markets of Ethiopia are mainly in countries with middle to high income per capita (e.g., Norway and Poland in Europe, and Canada and Mexico in North America).

Our counterfactual export promotion experiments should be regarded as a "proof of concept" for two reasons. First, our estimation strategy is based on choosing variable and fixed cost proxies that plausibly do not affect both.[3] Variable cost is proxied by bilateral distance. The fixed cost proxy is the regulation cost of firm entry. Future work on export promotion targeting should add to our inferred measures of variable and fixed costs any available direct trade cost measures. Variable and fixed cost counterfactuals can combine variation in such costs with the structural gravity parameters estimated with our methods.

A second reason for treating our estimates with care is that our estimator models the extensive margin only. The intensive margin operates through the proportion of firms already exporting. This proportion is not observed in our data at the required origin-sector-destination level. The potential omitted variable bias is small because the overall proportion of exporting firms is observed to be small, and necessarily smaller still for sectoral bilateral trade.[4] Future applications of AI gravity to data including firm-level

[3]Variables such as Free Trade Agreement membership, common language, common legal traditions, etc. affect both fixed and variable cost. Tariffs are directly a variable cost but may be systematically related to fixed costs (i.e., interest group pressures for tariffs are low in sectors where fixed costs already limit trade.)

[4]On average in our ISIC3 data, zeros account for 28% of bilateral trade flows among the world's 75

information can incorporate the intensive margin.

Our treatment of zero trade flows associated with flexible demand systems is distinguished from the preceding literature in its application to export promotion policy issues, while in a technical sense it is an extension of that literature. One treatment in the literature assumes away an extensive margin by modeling trade as a Poisson arrival process with zeros accounted for as events with no observed shipments in the observation window. A multi-sector extension of the Ricardian model with random productivity draws (Eaton et al., 2012) generates zeros at the sector level with a CES demand system (Costinot et al., 2012) without either fixed costs or choke prices. Allowing for an extensive margin associated with fixed costs implies that standard CES gravity estimators that exclude zero flows are potentially biased due to selection effects. Helpman, Melitz, and Rubinstein (2008) adopt the Heckman two-stage estimation procedure that uses an equation for selection of trade partners in the first stage and a trade flow equation in the second.[5] Baldwin and Harrigan (2011) add quality-selection to the Melitz (2003) model and, together with productivity-selection, show that only firms with the lowest quality-adjusted price export. Choke prices without fixed costs can be generated in quadratic demand systems, e.g., in Melitz and Ottaviano (2008). In contrast to AIDS, quadratic preferences do not generate a closed-form gravity model that can be estimated. Also, Pollak and Wales (1992) offer evidence that the translog somewhat outperforms the quadratic expenditure system in household budget studies. Novy (2013) uses the one-parameter translog demand system by Feenstra (2003) to derive a micro-founded gravity equation that features an endogenous trade cost elasticity and potential choke prices, but does not explore zeros since there are very few zeros in his sample.[6] This demand structure is the special case in which all goods enter "symmetrically".[7]

Our alternative AI gravity model implies that latent trade is associated with observed zeros, while the same model applies to positive trade flows. A Tobit estimator of AI gravity is thus appropriate, treating the zero flows as left-censored observations at zero.

largest economies in the year 2006. Details are in Section 2. For some large bilateral pairs the proportion of exporting firms may be discrete, so omitted variable bias is potentially significant. In future applications to HS10 digit trade, zeros are far more prominent and omitted intensive margin bias would be much less significant.

[5]Fixed costs of bilateral exporting combined with heterogeneously productive firms and CES demand are the explanation for zeros in influential literature based on Melitz (2003). Firms draw productivities from a bounded Pareto distribution. The value of the bound is essential to the model because there would be no zeros with a sufficiently high bound. In this sense, fixed cost alone explains zeros – sufficiently high variable cost cannot generate zeros in the CES structure with the elasticity of substitution greater than one.

[6]Novy (2013) uses aggregate exports among 28 OECD countries for the year 2000. Only seven of the bilateral observations are zeros.

[7]Also see Feenstra and Weinstein (2017).

In contrast to homothetic demand systems, choke prices can be due to the combined effect of high income-elasticity and low per capita income. The closest predecessor to our model is that of Fajgelbaum and Khandelwal (2016). They extend Feenstra's one-parameter translog to a non-homothetic AIDS gravity structure with income elasticities that can vary by source country. We extend their model to allow price (variable cost) elasticity heterogeneity across all N source countries.[8] Our version of AIDS allows variable cost to affect trade (including latent trade) flows differently across exporters. It is a reasonable compromise between parsimony and a realistic approximation of origin-specific variations in demand elasticity reflecting quality variations *inter alia*. Relative to Fajgelbaum and Khandelwal (2016), we find that allowing for price elasticity variation greatly reduces the significance of income effect variation. The more essential difference is that we focus on zeros with measures of latent trade.

Our paper is also related to a wider literature on zeros in international trade. Armenter and Koren (2014) propose a statistical model using balls and bins to account for the large number of zeros in firm- and product-level international shipments. Our economic structural model accounts for the same pattern in a setting from which policy implications are drawn. Eaton et al. (2012) show that the standard heterogeneous firm model can be modified to generate an integer number of firms that account for the zeros in bilateral trade data. Our model nests heterogeneous firms within a more general demand structure.

The remainder of the paper is organized as follows. The next section presents the zero flows in data. Section 3 derives the Almost Ideal gravity model. The model estimation is discussed in Section 4, and applied to quantify causes of the zero flows in Section 5. Section 6 conducts counterfactuals on export promotion policies. Section 7 is the robustness. Section 8 concludes. An appendix contains additional details on the derivation of the model, descriptions of the data and estimation, and added counterfactual details.

2 Zeros in the Data

We use trade and production data for the world's 75 largest economies in the year of 2006 sourced from CEPII.[9] The data record bilateral trade flows and production across 25 industrial sectors in the International Standard Industrial Classification (ISIC) Revision 2. Thus, there are 75*75 = 5625 country pairs (including domestic trade observations). On average, the frequency of zeros across all sectors and pairs is 28%. Figure 1 shows the

[8] The general bilateral price elasticity matrix of AIDS has $N \times (N-1)/2$ parameters in Deaton and Muellbauer (1980). AI gravity as applied here reduces the number of parameters to $N \times 1$.

[9] See Appendix Table B.1 for the country list.

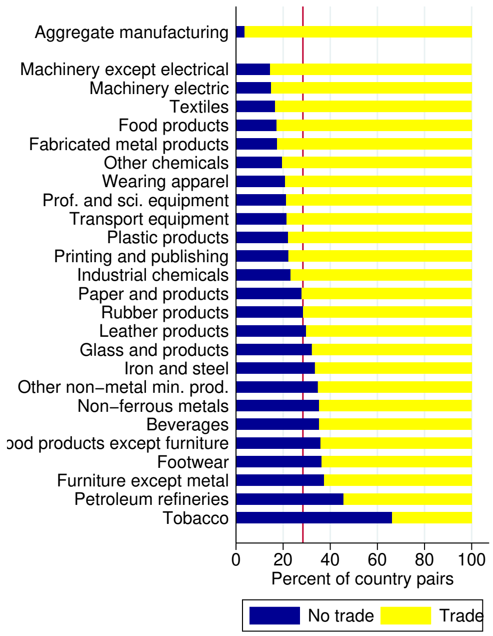

Figure 1: Zero Trade Frequency across Sectors

zero flow frequency in each sector. The zero flow frequency in the leather sector is closest to the average level. 15% of the country pairs do not trade machines. 65% of the trade flows in the tobacco sector among the country pairs are zero. Zero trade flows are more likely to occur in tobacco, petroleum, and furniture sectors, while less likely to occur in machinery, electric, and textile sectors.

Zeros could be simply a result of a group of countries not trading with one another. To dismiss this possibility, we take the "average" sector, leather, as an example.[10] Figure 2 plots the trade matrix among all importers (rows) and exporters (columns) in descending order ranked by GDP. So the first row (column) displays the U.S. import from (export to) each country (including itself). The second row (column) follows Japan and succeeding rows (columns) follow Germany, China, etc.[11] Again, the blue dots represent zero flows, and the yellow dots represent positive observations. The diagonal elements are the domestic trade of each country and are all positive. This implies that every country produces and supplies leather products to its domestic market. The general sparseness of the trade matrix is evident – the fraction of zero observations is around 30%, and almost all countries are associated with zero flows. More specifically, there are zero flows in every row (column), meaning that no one imports (exports) leather products from (to) every-

[10]The zero frequency of international trade in the leather sector is 30%, close to the average zero frequency of 28%.

[11]Note that the year is 2006 in our sample.

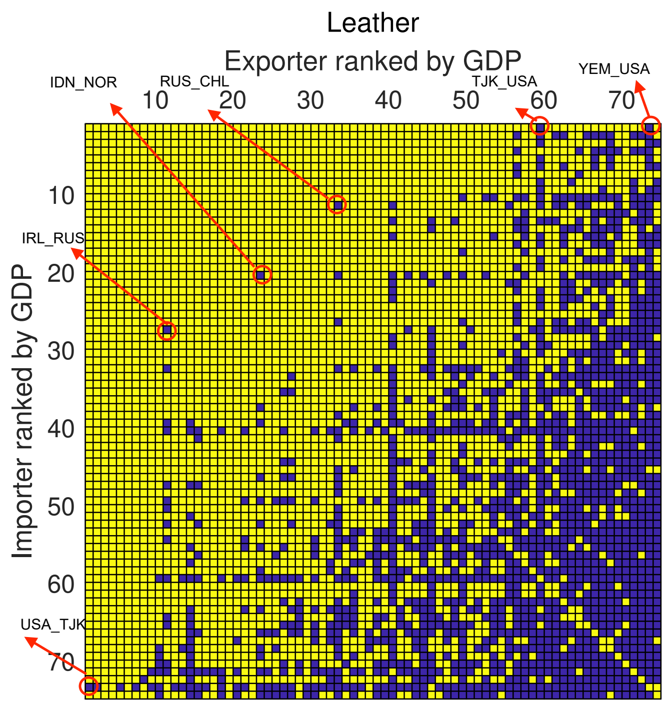

Figure 2: Zero Trade Flows by Country Pairs: Leather Sector

where. The two exceptions appear in the third and fourth columns – Germany and China export their leather products everywhere. Second, zero relationships are concentrated in the lower-right corner, implying that smaller countries are less likely to trade with each other. Third, the many zeros in the upper-right (lower-left) corner, which suggests that even large importers (exporters) are associated with many zeros. For example, the U.S. neither exports leather products to nor imports them from Tajikistan. The trade flow is also zero from the U.S. to Yemen. Furthermore, even some large economies do not trade leather goods with each other. For example, the observations from Russia to Ireland, from Chile to Russia, and from Norway to Indonesia are all zeros.

Although the zero frequency is different across sectors, the distribution pattern is very similar to that in the leather sector. The prevalence of zeros in sectoral trade does not just come about because of a certain group of countries, but every country is involved to some extent. (See Appendix Figures B.1-B.4 for the trade matrix of each sector).

3 Model

This section outlines a general equilibrium model and derives a gravity equation that can reconcile both positive and zero international trade flows.

3.1 Preferences

We consider a world economy with N countries, a continuum of goods $\omega \in \Omega$, and labor as the only factor of production. Denote the exporter as i and the importer as j. Consumers have the Almost Ideal Demand System (AIDS) preference introduced by Deaton and Muellbauer (1980), which can be rationalized as a non-homothetic second-order approximation to an arbitrary expenditure system. Specifically, in any country j, there is a representative consumer with an expenditure function given in logarithmic form as

$$\ln e_j = \ln Q_j + u_j \prod_{\omega \in \Omega} p_j(\omega)^{\phi(\omega)}, \tag{1}$$

where e_j is the minimum expenditure at which the consumer can obtain utility u_j given prices $p_j(\omega)$. The price index $\ln Q_j$ is given in logarithmic form as

$$\ln Q_j = \int_{\omega \in \Omega} \alpha(\omega) \ln p_j(\omega) d\omega + \frac{1}{2} \iint_{\omega, \omega' \in \Omega} \gamma(\omega, \omega') \ln p_j(\omega') \ln p_j(\omega) d\omega' d\omega. \tag{2}$$

To satisfy homogeneity of degree one, the parameters are constrained by $\alpha(\omega) \in (0,1)$, $\int \alpha(\omega)d\omega = 1$ and $\int \gamma(\omega,\omega')d\omega = 0$ for any ω'. Symmetry is imposed to satisfy Young's Theorem, $\gamma(\omega,\omega') = \gamma(\omega',\omega)$. Concavity is imposed by the requirement that $\{\gamma(\omega',\omega)\}$ is negative semi-definite.

We let

$$\gamma(\omega,\omega') = \begin{cases} \gamma\beta(\omega)\beta(\omega'), & \text{if } \omega \neq \omega' \\ -\gamma\beta(\omega)(1-\beta(\omega)), & \text{otherwise,} \end{cases} \tag{3}$$

where $\beta(\omega) \in (0,1)$ and $\int \beta(\omega)d\omega = 1$.[12] Specialization (3) satisfies the general restrictions of the AIDS but imposes a tight restriction on the cross-effects. In particular, complementarity is ruled out – all off-diagonal terms of the substitution effects matrix are non-negative.[13]

Applying Shephard's lemma and differentiating the expenditure function with respect to log price $p_j(\omega)$ generates the expenditure share in good ω for consumers at country j equal to

$$s_j(\omega) = \alpha(\omega) - \gamma\beta(\omega)\ln\left(\frac{p_j(\omega)}{\bar{p}_j}\right) + \phi(\omega)\ln r_j, \tag{4}$$

where

$$\ln \bar{p}_j = \int_{\omega\in\Omega} \beta(\omega)\ln p_j(\omega)d\omega. \tag{5}$$

These expenditure shares have some nice features. First, $\alpha(\omega)$ is a taste parameter for the good ω, which shifts the expenditure share independently from the prices and income. Second, $\gamma\beta(\omega)$ is the price elasticity for good ω. The variation of $\beta(\omega)$ allows for asymmetric demand responses to price changes. This gives AIDS preference CES-like components because the price terms $-\gamma\beta(\omega)\ln(p_j(\omega)/\bar{p}_j)$ captures cross-effects in substitution with the log of a ratio of own price to an average price $\bar{p}_j$. Third, $\phi(\omega)$ is the income elasticity which captures the non-homothetic component of the preference. Positive $\phi(\omega)$ implies luxury goods (with high quality) while negative $\phi(\omega)$ implies necessary goods (with low quality).[14] We refer to $r_j = e_j/Q_j$ as adjusted real income (expenditure) by individual price index. When $\phi(\omega) = 0$ for all ω, AIDS becomes the homothetic translog preference. When $\beta(\omega) = 0$ and $\phi(\omega) = 0$ for all ω, AIDS becomes the Cobb-

[12] This paper and Zhang (2020) were begun together applying the method in equation (3).

[13] $\beta(\omega) = \beta(\omega')$, $\alpha(\omega) = \alpha(\omega')$ for all ω and ω', is the special case proposed by Feenstra (2003) followed by Arkolakis et al. (2010), Novy (2013), and Fajgelbaum and Khandelwal (2016). Our specialization (3) allows for more price elasticity variation. Our estimation implies positive β estimates, consistent with the model.

[14] Note that $\gamma\beta(\omega)$ and $\phi(\omega)$ are semi-elasticities since they relate expenditure shares to logs of prices and income, but we refer to them as elasticities to save notation.

Douglas preference.

AIDS allows for reservation (choke) prices above which demand is equal to zero. For a single consumer in isolation, this implies difficulties in identifying the demand system, since reservation prices are unobservable for the unavailable goods (Feenstra, 2010), yet have effects on positive demand.[15] In the many country gravity context, all goods are consumed somewhere. Thus the demand parameters can be identified. We also can identify the trade cost that it would take to serve any bilateral market. The full price vector, including the reservation prices, is implicitly solved in the gravity model. The resulting effect on positive shares is controlled for by the destination fixed effects that control for the effect of variation in the full price vector via the theoretically founded price index (see Appendix A.1 for proof). This procedure essentially jumps over the unobserved reservation price problem.

For comparative static experiments of the sort we deploy in Section 6, the extensive margin changes and the response of the full price vector involves the shift from reservation prices to active market prices. Appendix A.1 analyzes this case with an extension of Feenstra (2010) to admit a higher dimensional class of substitution effect and to admit non-homothetic income effects in the latent goods group.

3.2 Firms

In any country i, there is a pool of monopolistically competitive firms. With the demand function (4), firm ω maximizes its profit $p_j(\omega)q_j(\omega) - \frac{w_i t_{ij}}{z(\omega)} q_j(\omega)$ where $q_j(\omega)$ is the quantity, $t_{ij} > 1$ reflects bilateral iceberg trade cost between country i and country j, and w_i is the wage rate. Assume symmetry across the varieties ω from country i such that $\alpha(\omega) = \alpha_i$, $\beta(\omega) = \beta_i$, and $\phi(\omega) = \phi_i$.

Assume firms cannot observe their productivities until they set their prices. This is because firms face a large cost of deviating from a posted price for many reasons, e.g., punishment by buyers. The assumption is fairly close to reality for many goods (household appliances, motor vehicles, bicycles, etc.). The firms in each country i draw productivities from the same distribution, so they set a common price, resulting in a common markup. Note that the markup can vary by country of origin.[16] The profit-maximizing markup is $1 + (\gamma\beta_i)^{-1}s_{ij}$ if markets are segmented. For simplicity, we assume that markets are not

[15] The reservation prices in principle are solved from the subset of goods for which there is no trade, then substituted back into the set of goods for which there is positive trade to control for their influence. This imposes considerable nonlinearity in parameters.

[16] In contrast, models of monopolistic competition with CES preferences require uniform markups by country of origin.

segmented,[17] hence arbitrage forces markups (over full cost of production and trade) by firms of country i to be the same across destinations. Firm ω from country i thus sets its markup based on the expected firm share in the world market which is denoted as $\bar{s}_i$. The common markup is denoted as μ_i. Thus

$$\mu_i = 1 + (\gamma\beta_i)^{-1}\bar{s}_i. \tag{6}$$

Then a firm receives a random productivity draw in log-level $\ln z$. Following the recent literature, denote $a = \ln z$ and assume a follows a special bounded Pareto distribution with accumulative density function as

$$G(a) = \frac{\ln a}{\ln H},\ 1 < a < H, \tag{7}$$

where 1 and H are the lower and upper bounds of the distribution, respectively.[18] Parameter H also reflects the dispersion of the productivity. The equilibrium price in log for markets that are served is

$$\ln p_{ij}(z) = \ln \mu_i w_i t_{ij} - \ln z. \tag{8}$$

From equation (4), firm z's market share in country j is

$$s_{ij}(z) = \alpha_i - \gamma\beta_i \ln(\mu_i w_i t_{ij}/\bar{p}_j) + \phi_i \ln r_j + \gamma\beta_i \ln z, \tag{9}$$

and its profit

$$\pi_{ij}(z) = (1 - \mu_i^{-1})s_{ij}(z)E_j - F_{ij}, \tag{10}$$

where E_j is the total expenditure of country j, F_{ij} denotes the fixed cost for firms from country i export to country j. Then from zero profit condition $\pi_{ij}(z_{ij}^*) = 0$, we can get the cutoff productivity in log is

$$\ln z_{ij}^* = (\gamma\beta_i)^{-1}[\frac{\mu_i}{\mu_i - 1} f_{ij} - \alpha_i + \gamma\beta_i \ln(\mu_i w_i t_{ij}/\bar{p}_j) - \phi_i \ln r_j], \tag{11}$$

where

$$f_{ij} = F_{ij}/E_j \tag{12}$$

[17] The assumption avoids having to deal with a complex endogeneity problem in firm-destination markups, but is also plausible for many sectors. Segmented markets require firm-destination-specific barriers that prevent spatial arbitrage. For many products, these seem unlikely. Nevertheless, the no segmentation assumption rules out pricing-to-market behavior observable in some well-known sectors.

[18] We normalize the lower bound as 1. Alternatively, we assume $G(a) = \frac{\ln a - \ln L}{\ln H - \ln L} = \frac{\ln(a/L)}{\ln(H/L)}$, $L < a < H$, which is equivalent to our setup.

denotes the adjusted fixed cost by the total market expenditure.

3.3 Aggregates

Let S_{ij} denote the total market share of country j imports from all firms of country i. By definition, the bilateral import share is

$$S_{ij} = N_i \int_{\ln z_{ij}^*}^{H} s_{ij}(a) dG(a), \tag{13}$$

where N_i is the measure of firms in country i. Here the total number of firms N_i are exogenous while the proportion that export is endogenous. Using the demand system structure and rearranging yields

$$S_{ij}/N_i = [\alpha_i - \gamma\beta_i \ln(\mu_i w_i t_{ij}/\bar{p}_j) + \phi_i \ln r_j] \int_{\ln z_{ij}^*}^{H} dG(a) + \gamma\beta_i \int_{\ln z_{ij}^*}^{H} a dG(a).$$

The first term on the right-hand side is the intensive margin of trade. The second term is the extensive margin of trade. Where firm-level data is available, the evidence shows that a small fraction of firms serve any destination market, all the more so when trade is sectorally disaggregated.[19] Due to the absence of data on the proportion of active firms in each sector bilateral market, we impose the simplifying assumption that $\int_{\ln z_{ij}^*}^{H} dG(a)$ is very small. This assumption suppresses the intensive margin. The resulting exclusive model of the extensive margin of trade flows $\gamma\beta_i \int_{\ln z_{ij}^*}^{H} a dG(a)$ is reasonably justified by the focus of this paper on latent (observed zeros) vs. low positive trade.

Then equation (9) and (11) give,[20]

$$S_{ij}/N_i = \alpha_i' - \gamma\beta_i' \ln(\mu_i w_i t_{ij}/\bar{p}_j) - \lambda_i' f_{ij} + \phi_i' \ln r_j, \tag{14}$$

where

$$\begin{aligned} \alpha_i' &= (1/\ln H)\alpha_i + (H/\ln H)\gamma\beta_i, && (15)\\ \beta_i' &= (1/\ln H)\beta_i, && (16)\\ \lambda_i' &= (1/\ln H)\mu_i/(\mu_i - 1), && (17)\\ \phi_i' &= (1/\ln H)\phi_i. && (18) \end{aligned}$$

[19] Bernard et al. (2007) investigate manufacturing firms across three-digit NAICS industries and find that the overall share of U.S. manufacturing firms that export is relatively small, at 18 percent.

[20] Proof in Appendix A.2.

Note that α_i', $\gamma\beta_i'$, and ϕ_i' are productivity-adjusted tastes, productivity-adjusted price elasticities, and productivity-adjusted income elasticities. Thus, $\alpha_i' > 0$, $\gamma\beta_i' > 0$. ϕ_i' and ϕ_i have the same sign. Relative to α_i, $\gamma\beta_i$, and ϕ_i, they include dependence on the supply side productivity distribution parameter H. Finally λ_i' is the marginal effect of fixed cost on trade shares. The coefficients satisfy $\sum_i N_i\alpha_i' = (1/\ln H) + (H/\ln H)\gamma$, $\sum_i N_i\beta_i' = (1/\ln H)$, and $\sum_i N_i\phi_i' = 0$. And thus $\beta_i = \beta_i'/\sum_i N_i\beta_i'$. Note that the total number of firms N_i is exogeneously given, but the fraction of firms that export is endogenously determined.[21] The main parametric action in our model is on the demand side. The supply side productivity dispersion parameter plays a role in the implied trade elasticities.[22] Aggregate share per firm in (14) is decomposed into four parts. The first term α_i' includes all origin-specific factors, and the last term $\phi_i' \ln r_j$ includes all destination-specific factors multiplied by an origin-specific coefficient. The two terms in the middle are the effects of bilateral variable costs and fixed costs.

3.4 Gravity

Market clearance for each origin i is given by

$$Y_i = \sum_j S_{ij} E_j, \tag{19}$$

where Y_i is the total income of country i. Using market clearance in the AIDS share equation yields the AI gravity equation.[23] Thus:

$$S_{ij}/N_i - \frac{Y_i}{Y}/N_i = -\gamma\beta_i' \ln(\frac{t_{ij}}{\Pi_i P_j}) - \lambda_i'(f_{ij} - \Psi_i) + \phi_i' \ln(r_j/R), \tag{20}$$

where Y is world total income, and

$$\ln \Pi_i \equiv \sum_j (E_j/Y) \ln t_{ij}, \tag{21}$$

$$\ln P_j \equiv \sum_i N_i \beta_i \ln(t_{ij}/\Pi_i), \tag{22}$$

[21] The endogenous fraction of exporting firms is also in the firm heterogeneity models of Chaney (2008) and Novy (2013).

[22] The productivity distribution is invariant across countries in our model. We could allow productivity distribution location parameter, H, to be origin-specific, but its variation is absorbed into productivity-adjusted elasticities. The standard Pareto shape (dispersion) parameter is set equal to 1 to linearize the resulting reduced form model.

[23] Proof in Appendix A.3.

$$\Psi_i \equiv \sum_j (E_j/Y) f_{ij}, \tag{23}$$

$$\ln R \equiv \sum_j (E_j/Y) \ln r_j. \tag{24}$$

On the left hand side, $S_{ij}/N_i - \frac{Y_i}{Y}/N_i$ is the deviation of bilateral trade per firm from its frictionless level $\frac{Y_i}{Y}/N_i$. There are three terms on the right hand side, which capture the *variable cost effect*, *fixed cost effect*, and *income effect*, respectively. The first term, $-\gamma\beta_i \ln\left(\frac{t_{ij}}{\Pi_i P_j}\right)$, is the effect of relative bilateral trade resistance from origin i to destination j where $\ln \Pi_i$ and $\ln P_j$ are the outward and inward multilateral resistances in logs, respectively. The relative resistance term is very similar to the CES structural gravity of Anderson and van Wincoop (2003). The last term, $\phi_i \ln(r_j/R)$, is the non-homothetic component of the gravity equation and captures the effect of relative income per capita of market j where $\ln R$ is the average world income per capita in log.

The middle term, $-\lambda_i'(f_{ij} - \Psi_i)$ exploits the AI structure to capture the effect of relative trade "fixed cost" that reduces bilateral trade via the firm-level extensive margin from origin i to destination j. The intuition is that fixed cost raises the market entry barrier and fewer firms export. We refer to Ψ_i as the outward "multilateral fixed resistance" that summarizes the average trade fixed cost between a country and its trading partners.

We dub equation system (20)-(24) the Almost Ideal (AI) gravity model. The name naturally refers to its base in the Almost Ideal Demand System and connotes that (20)-(24) is the most flexible and complete gravity model in the literature thus far: (i) AI gravity includes both variable and fixed trade costs; (ii) AI gravity incorporates both the intensive margin and the extensive margin of trade; (iii) AI gravity has non-homothetic components; (iv) AI gravity allows for asymmetric price elasticities across exporters; and (v) AI gravity can generate latent trade flows analytically.[24] System (20)-(24) retains the desirable properties of the received literature in reducing equilibrium spatial arbitrage between M origins and M destinations, involving M^2 bilateral relationships, to a set of M inward and $2M$ outward multilateral resistances. Compared to the CES case with only M outward multilateral resistances, fixed export costs add an equilibrium multilateral fixed cost resistance term. It is useful to confirm that system (20)-(24) satisfies the requirement of homogeneity of degree zero in variable trade costs – a scalar rise in all t_{ij}s by proportion τ leaves $t_{ij}/\Pi_i P_j$ unchanged. In contrast, a scalar rise in all f_{ij} raises Ψ_i in the same proportion, thus $f_{ij} - \Psi_i$ is changed in this proportion.

[24] When β_i' is constant and λ_i' is zero for all i, AI gravity becomes the special case proposed by Fajgelbaum and Khandelwal (2016).

4 Estimation

The estimation of AI gravity derived in Section 3 is described in this section. Section 4.1 describes the data and specifications. Estimation results using aggregate trade data are presented in Section 4.2 and results using sectoral trade data are presented in Section 4.3.

4.1 Data and Specifications

Trade and production data for 75 countries in the year 2006 comprise the sample.[25] We follow Novy (2013) to measure the number of goods that originate from each country, N_i, with the extensive margin data constructed by Hummels and Klenow (2005). The extensive margin is measured by weighting categories of goods by their overall importance in exports.[26]

Bilateral variable cost is projected by

$$\ln t_{ij} = \rho \ln dist_{ij} + \varepsilon_{ij}^{t}, \tag{25}$$

where d_{ij} is bilateral distance as calculated by CEPII, ρ is the elasticity of trade cost to distance, and ε_{ij}^{t} is the error term.

The fixed trade cost is measured by the regulation costs of firm entry collected by Djankov et al. (2002), following Helpman et al. (2008). These entry costs are measured via their effects on the number of days, the number of legal procedures, and the relative cost (as a percentage of GDP per capita) for an entrepreneur to legally start operating a business. We use the monetary cost in our baseline estimation and non-monetary costs in the robustness check.[27] Moreover, we construct the bilateral fixed cost as the average cost for an entrepreneur to start a business in the exporter and the importer country. Thus it is country-pair specific. Then we divide this cost by the importer's total expenditure, according to equation (12), to compute the adjusted bilateral entry cost f_{ij}.

A key estimation problem faced by all attempts using gravity to separate inferred fixed from variable costs is the need to find proxies that arguably do not affect both. Our proxy for the variable cost is bilateral distance.[28] We augment the variable and fixed cost proxies with a uniform cross-border friction that in principle combines both variable and

[25] Details are discussed in Section 2.

[26] We also use other measures for the number of goods as robustness checks in Section 7.1.

[27] See Section 7.2.

[28] Many of the standard proxy variables in the gravity literature reflect both. For example, trade partnerships and common language very likely affect both fixed and variable trade costs. Even tariffs could reflect both if high fixed cost in protectionist countries is associated with low tariffs.

fixed cost components.

Recall that real expenditure per capita is defined as $\ln r_j = \ln(e_j/\bar{Q}_j)$ where e_j, nominal expenditures per capita, are observable. Aggregate price index $\ln \bar{Q}_j$ can be proxied by a Stone index following the literature,[29] that is

$$\ln \bar{Q}_j = \sum_{i=1}^{N} S_{ij} \ln(p_{ii} dist_{ij}^{\rho_0}), \tag{26}$$

where p_{ii} are the quality-adjusted prices estimated by Feenstra and Romalis (2014). We pick $\rho_0 = 0.177$ following Fajgelbaum and Khandelwal (2016).

The AI gravity equation derived above is

$$S_{ij}/N_i - \frac{Y_i}{Y}/N_i = -\gamma\beta_i' \ln(\frac{t_{ij}}{\Pi_i P_j}) - \lambda_i'(f_{ij} - \Psi_i) + \phi_i' \ln(r_j/R),$$

where there are a large number of parameters to be estimated. There is a set of productivity-adjusted variable cost (price) elasticities $\{\gamma\beta_i'\}$, a set of fixed cost elasticity parameters $\{\lambda_i'\}$, and a set of productivity-adjusted income elasticities $\{\phi_i'\}$. In order to reduce the number of estimated parameters, we impose some restrictions. First, we impose the constraint $\phi_i' = c_0 + c \ln r_i$ where $c > 0$ and r_i is the exporter income, similar to Fajgelbaum and Khandelwal (2016). This is because rich countries are more likely to export high-quality goods. The theoretical restriction $\sum_{i=1}^{N} N_i \phi_i = 0$ implies $c_0 = -c \sum_{i=1}^{N} N_i \ln r_i$, transforming this linear relationship to

$$\phi_i' = c(\ln r_i - \ln \bar{r}), \tag{27}$$

where $\ln \bar{r} = \sum_{k=1}^{N} N_k \ln r_k$, and reducing the number of productivity-adjusted income elasticities to be estimated from N to one, i.e., coefficient c.

Second, we assume productivity-adjusted price elasticities are also correlated to exporter income. Specifically

$$\gamma\beta_i' = b_0 - b_1 \ln r_i, \tag{28}$$

where r_i is the GDP per capita of the exporting country i and $b_1 > 0$.[30] Poor countries are more likely to export price-elastic goods. Then we reduce the number of productivity-adjusted price elasticities to be estimated from N to 2, i.e., coefficients b_0 and b_1.

Third, the structural model suggests that the coefficient on fixed cost is a function of

[29] Deaton and Muellbauer (1980) were first to use a Stone index to proxy the AIDS price index. The trade literature, like Atkin (2013) and Fajgelbaum and Khandelwal (2016), uses this approximation.

[30] Novy (2013) and Fajgelbaum and Khandelwal (2016) assume symmetric price elasticities, i.e., $b_1 = 0$.

the markup in equation (17), and thus a function of the price elasticity parameters implied in equation (6). Then we have

$$\lambda_i' = (1/\ln H)(1 + \gamma\beta_i/\bar{s}_i). \tag{29}$$

Since the fixed cost coefficient is linear in the price elasticity, we can estimate λ_i' in a similar way to distance elasticities. Specifically, similar to (28), we assume

$$\lambda_i' = b_0^f - b_1^f \ln r_i, \tag{30}$$

where r_i is the exporter income of exporter i and $b_1^f > 0$. The rich country's goods are more likely to have a smaller price elasticity, a higher markup, and thus a smaller fixed cost effect on trade compared with those of the poor country's goods.

The AI gravity model incorporates zeros and action on the extensive margin because it theoretically generates both positive and non-positive trade flows to match non-zeros and zeros in data. The Tobit method is thus appropriate to estimate AI gravity. A potential import share could be negative when the associated bilateral trade barriers are large enough. Since the negative share is censored at zero in the data, S_{ij} in the AI gravity equation is the latent value of the systematic (observed) trade share. If we denote the observed import share in data as $\tilde{S}_{ij}$, then

$$\tilde{S}_{ij}/N_i = \begin{cases} S_{ij}/N_i, & \text{if } S_{ij} \geq 0 \\ 0, & \text{if } S_{ij} < 0. \end{cases} \tag{31}$$

Note that (31) can be estimated using the Tobit model given the censoring mechanism.[31]

The specification of the AI gravity equation under the preceding restrictions becomes

$$S_{ij}/N_i = -b_0\rho \ln dist_{ij} + b_1\rho \ln r_i \times \ln dist_{ij} - b_0^f entrycost_{ij} + b_1^f \ln r_i \times entrycost_{ij}$$
$$+ c \ln r_i \times \ln r_j + \delta Internal_{ij} + b_1 \ln P_j \times \ln r_i + fe_i + fe_j + \varepsilon_{ij}, \tag{32}$$

where $fe_i = \frac{Y_i}{Y}/N_i + (b_0 - b_1 \ln r_i)\ln \Pi_i + \lambda' \Psi_i - \phi_i' \ln R$, and $fe_j = b_0\rho \ln P_j - c \ln r_j \times \ln \bar{r}$ are exporter- and importer-specific fixed effects. The multilateral resistance terms $\ln P_j$ are not observable since they have inside parameters $\{\beta_i\}_{i=1}^N$. But $b_1 \ln P_j$ can be controlled by exporter-specific coefficients on $\ln r_i$. We also add a dummy variable $Internal_{ij}$, which is

[31] Helpman, Melitz, and Rubinstein (2008) also pointed out the potential use of the Tobit model. If such zero trade values were just the outcome of censoring, then a Tobit specification would provide the best fit to the data.

0 for import and 1 for internal trade, to capture all the other unobserved trade cost across border, similar to Ramondo et al. (2016) and Anderson and Yotov (2017). Unfortunately ρ cannot be identified from b_0 and b_1. So we pick $\rho = 0.117$ directly following the literature, and then b_0 and b_1 are identified. We expect the coefficients of $\ln dist_{ij}$ and $entrycost_{ij}$ are both negative, while those of the interaction terms $\ln r_i \times \ln dist_{ij}$, $\ln r_i \times entrycost_{ij}$, and $\ln r_i \times \ln r_j$ are all positive. In other word, all parameter estimates $\{b_0, b_1, b_0^f, b_1^f, \lambda, c\}$ should be positive. The productivity-adjusted elasticity parameters are identified by

$$\begin{aligned} \gamma\beta_i' &= b_0 - b_1 \ln r_i, \\ \lambda_i' &= b_0^f - b_1^f \ln r_i, \\ \phi_i' &= c \ln(r_i/\bar{r}). \end{aligned}$$

Unfortunately, γ and β_i' cannot be identified form each other. The original demand parameters ϕ_i cannot be identified from the productivity distribution parameter H. But the original β_i are identified by

$$\beta_i = (b_0 - b_1 \ln r_i) / \sum_k N_k (b_0 - b_1 \ln r_k). \tag{33}$$

To investigate more extreme variation of zero trade flows, we estimate sectoral AI gravity equations using disaggregated data. Specifically, we estimate

$$\begin{aligned} S_{ij}^k/N_i = &-b_0^k \rho \ln dist_{ij} + b_1^k \rho \ln r_i \times \ln dist_{ij} - (b_0^f)^k entrycost_{ij} + (b_1^f)^k \ln r_i \times entrycost_{ij} \\ &+ c^k \ln r_i \times \ln r_j + \delta^k Internal_{ij} + b_1^k \ln P_j^k \times \ln r_i + fe_i^k + fe_j^k + \varepsilon_{ij}^k, \end{aligned} \tag{34}$$

where all variables with a superscript k are defined in the same way to those without any superscript but in sector k. Distance is constant across sectors. Since the sectoral data on entry cost and extensive margin are not available, we use the same measure as those in the aggregate estimation. We run the regression separately with corresponding data and obtain the estimates sector by sector.

4.2 Aggregate Results

We begin by estimating the AI gravity model in equation (32) with aggregate manufacturing trade data. The results are reported in column (1) in Table 1. The estimated exporter- and importer-specific fixed effects are dropped since they are not the parameters of interest. As always in gravity estimation, the coefficient of distance is significantly negative –

distance reduces the bilateral trade share. AIDS gravity fits the smaller shares better than CES. Novy (2013) finds that the translog model generates a reasonably good fit for intermediate import shares in the range from 0.05 to 0.15. He points out that for large import shares both CES and translog models produce larger residuals, and the translog model in particular underpredicts the actual import shares. Since 99.7% of the import shares in our sample are below 0.15, the AI gravity estimates are consistent with Novy (2013).

A more novel result is that the coefficient of the interaction term of distance and exporter income is significantly positive, implying that the distance reduces trade by less for rich exporters than for poor exporters. This suggests that there is a significant distance (price) elasticity heterogeneity across exporters, and the magnitude of the coefficient reflects the size of the distance elasticity dispersion. Since we assume that $\rho = 0.177$, the estimates imply that $\hat{b}_0 = 1.158/0.177 = 6.542$ and $\hat{b}_1 = 0.128/0.177 = 0.723$. Thus the productivity-adjusted variable cost (price) elasticity is $\widehat{\gamma\beta_i'} = \hat{b}_0 - \hat{b}_1 \ln r_i$, where r_i is exporter GDP per capita. And $\{\hat{\beta}_i\}_{i=1}^N$ can be calculated from equation (33). As discussed earlier, γ and H cannot be identified from their estimated product.

The coefficient of entry cost is significantly negative, which implies that the entry cost also reduces the bilateral trade share. The estimates imply that $\hat{b}_0^f = 5.805$ and $\hat{b}_1^f = 0.550$. Thus the productivity-adjusted fixed cost elasticity is $\widehat{\lambda}' = \hat{b}_0^f - \hat{b}_1^f \ln r_i$. The coefficient of the income interaction term is not significantly different from zero. This suggests that there is little income elasticity heterogeneity across exporters – non-homotheticity is not statistically significant in aggregate trade. The income elasticity parameter $\hat{c} = 0.017$. This positive coefficient implies that richer importers (higher $\ln r_j$) are more likely to spend larger shares on products from richer exporters (higher $\ln r_i$), conditional on trade costs. The productivity-adjusted income elasticity is $\hat{\phi}_i' = \hat{c} \ln(r_i/\bar{r})$.[32] The coefficient of the internal trade dummy is also significant, implying that the internal trade share is larger given all else equal. This home-bias term picks up all the relevant forces that discriminate between internal and international trade.

The interpretation of the Tobit estimates for latent trade is not straightforward. The Tobit coefficient estimates the linear increase of the latent variable for each unit increase of the predictor. As the latent variable is identical to the observed variable for all observations that are above the threshold, it also measures the linear increase of the predictor on the response for all observations above that threshold.[33] For example, the estimated

[32] Note that the $\hat{\phi}_i'$s are semi income elasticities, which measure the deviations from the unitary elasticity. We call them income elasticities to save notation, as discussed earlier. The actual income elasticities are $1 + \hat{\phi}_i/(S_{ij}/N_i)$.

[33] See Wooldridge (2010) for detailed explanations of the Tobit model and how to calculate the conditional expectation for the variable of interest.

Table 1: AI Gravity Estimation: Baseline

Import share per firm	(1) Tobit	(2) OLS	(3) Heckit
Distance	-1.158***	-1.131***	-1.115***
	(0.026)	(0.025)	(0.026)
Distance × Income_ex	0.128***	0.126***	0.124***
	(0.003)	(0.003)	(0.003)
Entry cost	-5.805***	-4.195***	-6.012***
	(0.893)	(0.798)	(0.947)
Entry cost × Income_ex	0.550***	0.397***	0.573***
	(0.088)	(0.079)	(0.093)
Income_im × Income_ex	0.017	0.025	0.058**
	(0.021)	(0.021)	(0.023)
Internal	2.829***	2.896***	2.870***
	(0.080)	(0.080)	(0.080)
$\hat{\sigma}$	0.121***		
	(0.002)		
Mills			-0.117**
			(0.047)
Observations	5625	5625	5625
R-squared	0.576	0.642	
Log-likelihood value	-2078.929	-1938.263	

Notes: Table reports the estimates of the AI gravity in equation (32) using aggregated manufacturing trade data. Estimated exporter- and importer-specific fixed effects are dropped. Robust standard errors in parentheses. Significance * .10, ** .05, *** .01.

coefficient of entry cost, -(5.805-0.550 $\ln r_i$), is the marginal effect of the entry cost on the latent share S_{ij}/N_i, as well as its the marginal effect on the observed trade share $\tilde{S}_{ij}/N_i$ above zeros. The slope for zero observations is different from this number. The Tobit model suggests that the average marginal effect of the predictor on the response for all observations is equal to its marginal effect on the latent variable multiplied by an adjustment factor. With the estimated standard deviation of the error term, $\hat{\sigma}$, we can compute the adjustment factor. Its value is about 0.504, evaluated at the estimates and the mean values of independent variables.[34] Thus the average marginal effect of entry cost on the observed trade share $\tilde{S}_{ij}/N_i$ is -0.504×(5.805-0.550 $\ln r_i$). Similarly, taking the interaction term into account, a one percent increase in distance leads to a decrease of (1.158-0.128 $\ln r_i$) in the latent trade share S_{ij}/N_i, in contrast to a decrease of 0.504×(1.158-0.128 $\ln r_i$) in observed trade share $\tilde{S}_{ij}/N_i$. For example, China's GDP per capita in log is 7.62 and thus the average marginal effect of log distance on the observed import share from China is -0.092. The Tobit estimates are related to but differ from the OLS results reported in column (2). The Tobit coefficient estimates have the same sign as the corresponding OLS estimates, and the statistical significance of the estimates is similar. The similarity arises because the aggregated manufacturing sample has a very low proportion of zero trade flows. But directly comparing the coefficients with the Tobit estimates is not informative.

As a robustness check, we compare the Tobit estimates with the Heckman two-stage method (Heckit) which regards the zero flows as missing values. Similar to Helpman, Melitz, and Rubinstein (2008), the first stage estimates the inverse Mills ratio using a probit model. The second stage runs an OLS estimation by adding the inverse Mills ratio into the regressors. The results are reported in column (3).[35] All coefficients have the intuitive signs. The coefficient of the inverse Mills ratio is significant, which implies there is a sample selection bias when dropping the zero flows in the gravity estimation. This result confirms the systematic nature of the extensive margin, and suggests applying the richer structure of AI gravity using the Tobit estimator. Although there are very few zeros in the aggregate trade flows, there are sizable differences in results between OLS, Heckit and Tobit estimators. The differences are even more significant in the sectoral estimation, where zero frequencies are higher.

We also report the estimates of AI gravity with different elasticity specifications in Table 2 to compare our baseline specification estimates with the results under the specifications of Fajgelbaum and Khandelwal (2016) and Novy (2013) along with other variations. The results under their specifications run on our data are similar to their results,

[34]In the Tobit model, the adjustment factor of the coefficient is $\Phi(\mathbf{xb}/\sigma)$.

[35]See Heckman (1979) for detailed explanations of the inverse Mills ratio.

Table 2: AI Gravity Estimation: Specifications

	(1)	(2)	(3)	(4)	(5)	(6)
Import share per firm						
Distance	-1.158***	-0.038***	-1.158***	-0.041***	-0.037***	-0.043***
	(0.026)	(0.010)	(0.026)	(0.009)	(0.010)	(0.009)
Distance × Income_ex	0.128***		0.128***			
	(0.003)		(0.003)			
Entry cost	-5.805***	-0.316***	-5.805***	-0.353***		
	(0.893)	(0.098)	(0.893)	(0.096)		
Entry cost × Income_ex	0.550***		0.550***			
	(0.088)		(0.088)			
Income_im × Income_ex	0.017	0.004*			0.006**	
	(0.021)	(0.002)			(0.002)	
Internal	2.829***	3.024***	2.829***	3.000***	3.038***	3.003***
	(0.080)	(0.095)	(0.080)	(0.094)	(0.095)	(0.094)
Observations	5625	5625	5625	5625	5625	5625
R-squared	0.576	0.352	0.576	0.352	0.351	0.350

Notes: Table reports the estimates of the AI gravity in equation (32) with different specifications. Estimated exporter- and importer-specific fixed effects are dropped. Robust standard errors in parentheses. Significance * .10, ** .05, *** .01.

assuring that our differences are due to specification rather than data. Column (1) is our baseline result for equation (32). In column (2), we drop the elasticity heterogeneity term measured by the interaction with exporter income, yielding a distance elasticity equal to -0.038.[36] The coefficients on distance and its interaction with exporter income are robust for the translog model in which the non-homothetic term is dropped as shown in column (3). When we further shut down the elasticity heterogeneity, as shown in column (4), all coefficients remain significant with intuitive signs.

We check our results with Fajgelbaum and Khandelwal (2016) by keeping the distance and non-homothetic terms as shown in column (5), and with Novy (2013) by keeping only distance as shown in the last column. The coefficients of distance are robust compared with column (2). The coefficient of the income interaction term in column (5) is 0.006 and significant, very close to the 0.0057 in Fajgelbaum and Khandelwal (2016), despite the different sample used in our paper. The biggest difference between our paper and Fajgelbaum and Khandelwal (2016) is the interaction term of distance and exporter's income. Column (1) and (2) show that the distance elasticity heterogeneity in our model makes the income effect heterogeneity less significant. In contrast, Fajgelbaum and Khandelwal (2016) focus by assumption solely on the income effect heterogeneity.

4.3 Sectoral Results

We report AI gravity estimates by sectors in row (2)-(26) of Table 3. For reference, the aggregate estimation results are reported again in row (1), equal to column (1) in Table 1. The sectors are sorted in descending order by the coefficient of the interaction term of distance and exporter income. Overall, the disaggregated AI gravity model works well. The coefficients of the variables are, in most cases, significant and the estimates vary across sectors in a sensible way.

First, distance is a large impediment to sectoral trade: all estimated distance coefficients are negative and statistically significant. Distance elasticities vary greatly across sectors, consistently with variation in value to weight and the physical requirements of transportation. All the coefficients of the interaction term of distance and exporter income are significantly positive, implying that the distance elasticity heterogeneity is common across all sectors. Products produced by richer exporters are less distance elastic. The coefficients of this interaction term are different in magnitude, which suggests different sizes of the distance elasticity dispersion. The largest value of this coefficient is 0.27 and

[36] The estimate of the distance elasticity is -0.025 in Novy (2013) and -0.043 in Fajgelbaum and Khandelwal (2016). Our result is in between.

Table 3: AI Gravity Estimation by Sector

Import share per firm		Distance	Distance ×Inc_ex	Entry cost	Entry cost ×Inc_ex	Inc_im ×Inc_ex	Internal	Obs.	R-sq.
(1)	Aggregate	-1.16***	0.13***	-5.81***	0.55***	0.02	2.83***	5625	0.58
		(0.03)	(0.00)	(0.89)	(0.09)	(0.02)	(0.08)		
(2)	Furniture	-2.59***	0.27***	-31.60***	3.04***	0.13**	4.44***	5625	0.34
		(0.06)	(0.01)	(3.28)	(0.32)	(0.06)	(0.20)		
(3)	Beverages	-2.48***	0.26***	-18.46***	1.77***	0.05	3.65***	5625	0.34
		(0.06)	(0.01)	(2.77)	(0.27)	(0.05)	(0.18)		
(4)	Tobacco	-2.73***	0.25***	-17.60***	1.65***	0.09	0.98***	5625	0.35
		(0.08)	(0.01)	(4.44)	(0.43)	(0.08)	(0.25)		
(5)	NonMetal	-2.10***	0.22***	-10.45***	1.01***	0.02	3.35***	5625	0.32
		(0.06)	(0.01)	(2.57)	(0.25)	(0.05)	(0.18)		
(6)	Petroleum	-2.26***	0.22***	-13.76***	1.32***	-0.01	1.30***	5625	0.29
		(0.07)	(0.01)	(3.31)	(0.32)	(0.06)	(0.20)		
(7)	Leather	-1.72***	0.18***	-16.55***	1.61***	0.12***	1.61***	5625	0.27
		(0.05)	(0.01)	(2.35)	(0.23)	(0.05)	(0.16)		
(8)	Food	-1.67***	0.18***	-9.34***	0.88***	0.01	3.73***	5625	0.36
		(0.04)	(0.00)	(1.61)	(0.16)	(0.04)	(0.13)		
(9)	Plastic	-1.60***	0.17***	-12.30***	1.18***	0.04	2.34***	5625	0.34
		(0.04)	(0.00)	(1.76)	(0.17)	(0.04)	(0.13)		
(10)	NfMetals	-1.59***	0.16***	-33.16***	3.20***	0.10***	1.28***	5625	0.35
		(0.04)	(0.00)	(2.34)	(0.23)	(0.04)	(0.13)		
(11)	Printing	-1.35***	0.14***	-6.61***	0.62***	-0.05	3.77***	5625	0.37
		(0.04)	(0.00)	(1.65)	(0.16)	(0.04)	(0.13)		
(12)	Wood	-1.36***	0.14***	-11.53***	1.11***	0.04	1.94***	5625	0.49
		(0.03)	(0.00)	(1.65)	(0.16)	(0.03)	(0.10)		
(13)	Glass	-1.40***	0.14***	-20.69***	1.99***	0.14***	2.17***	5625	0.37
		(0.04)	(0.00)	(2.01)	(0.19)	(0.04)	(0.13)		
(14)	Transport	-1.08***	0.12***	-16.14***	1.55***	0.07***	1.63***	5625	0.63
		(0.02)	(0.00)	(1.06)	(0.10)	(0.02)	(0.07)		
(15)	Footwear	-1.15***	0.12***	-4.49***	0.44***	-0.00	1.09***	5625	0.40
		(0.03)	(0.00)	(1.60)	(0.16)	(0.03)	(0.11)		
(16)	Apparel	-1.13***	0.12***	-10.55***	1.03***	0.06***	1.87***	5625	0.60
		(0.02)	(0.00)	(1.03)	(0.10)	(0.02)	(0.08)		
(17)	Paper	-1.04***	0.11***	-4.74***	0.46***	0.04*	1.45***	5625	0.50
		(0.03)	(0.00)	(1.17)	(0.11)	(0.02)	(0.09)		
(18)	IronSteel	-1.01***	0.10***	-17.75***	1.70***	0.03	1.72***	5625	0.42
		(0.03)	(0.00)	(1.77)	(0.17)	(0.03)	(0.10)		
(19)	OthChem	-0.97***	0.10***	-1.07	0.10	-0.01	1.45***	5625	0.69
		(0.02)	(0.00)	(0.80)	(0.08)	(0.02)	(0.07)		
(20)	ProfSci	-0.82***	0.09***	-2.78**	0.26**	-0.02	1.23***	5625	0.32
		(0.03)	(0.00)	(1.25)	(0.12)	(0.03)	(0.10)		
(21)	Textiles	-0.90***	0.09***	-12.91***	1.25***	0.01	1.69***	5625	0.57
		(0.02)	(0.00)	(1.02)	(0.10)	(0.02)	(0.07)		
(22)	Electrics	-0.67***	0.07***	-1.89*	0.17	0.02	1.32***	5625	0.28
		(0.03)	(0.00)	(1.13)	(0.11)	(0.03)	(0.10)		
(23)	IndChem	-0.58***	0.06***	-9.31***	0.89***	0.05***	1.59***	5625	0.57
		(0.02)	(0.00)	(1.02)	(0.10)	(0.02)	(0.07)		
(24)	Machines	-0.57***	0.06***	-9.89***	0.96***	0.08***	0.95***	5625	0.57
		(0.02)	(0.00)	(0.83)	(0.08)	(0.02)	(0.07)		
(25)	MetalProd	-0.61***	0.06***	-2.02**	0.18**	0.05**	1.77***	5625	0.55
		(0.02)	(0.00)	(0.90)	(0.09)	(0.02)	(0.07)		
(26)	Rubber	-0.66***	0.06***	-3.86***	0.36***	0.08***	1.24***	5625	0.39
		(0.03)	(0.00)	(1.23)	(0.12)	(0.02)	(0.09)		

Notes: Table reports the estimates of the sectoral AI gravity in equation (34). Estimated exporter- and importer-specific fixed effects are dropped. Robust standard errors in parentheses. Significance * .10, ** .05, *** .01.

is almost five times as large as the smallest value, 0.06, which implies a big difference in the price elasticity dispersion among sectors. Furniture, beverage, and tobacco products are the three sectors with the biggest distance elasticity heterogeneity, while rubber, metals, and machinery are among the sectors with the smallest distance elasticity dispersion. This is intuitive because products in the former sectors are more differentiated than those in the latter sectors. Second, most of the coefficients of the interaction term of entry cost and exporter income are significantly positive, implying that the fixed cost elasticity heterogeneity is also common across all sectors. Third, most estimated coefficients of the income interaction term are positive, but only eleven of them are significant. This suggests that the non-homothetic effect is weak in most sectors. Significant non-homothetic income effects are found in sectors like glass and furniture products. In these sectors, richer countries are more likely to export high-quality goods and also more likely to import high-quality goods. Last, international borders reduce trade, all else equal. All the estimates of the coefficients on internal (the dummy variable capturing border effect) are positive, large, and significant at any level. Furniture, printing, food, and beverage products are the sectors with the highest internal estimate, while machines and tobacco are the ones with the lowest estimate. This is intuitive because the other unobserved trade barriers, like consumer tastes, play an important role in the former sectors while are weak in the latter.

5 Zeros and the Roles of Variable and Fixed Costs

In this section, we use the estimation results from Section 4 to quantify the roles of variable and fixed costs in causing international zero trade flows. Section 5.1 constructs a hypothetical negative trade variable that measures how far from trade a non-partner relationship is. In Section 5.2, we decompose the variation in the hypothetical trade measure into a variable cost component, a fixed cost component, and an income effect component.

5.1 Latent Trade

How can we understand the latent value of bilateral trade censored at zero in the setting of our model? A diagram illustrates the micro-structure of this unobservable negative value.

Recall that demand $q_{ij}(z)$ for good z from i sold in j is implied as a decreasing function

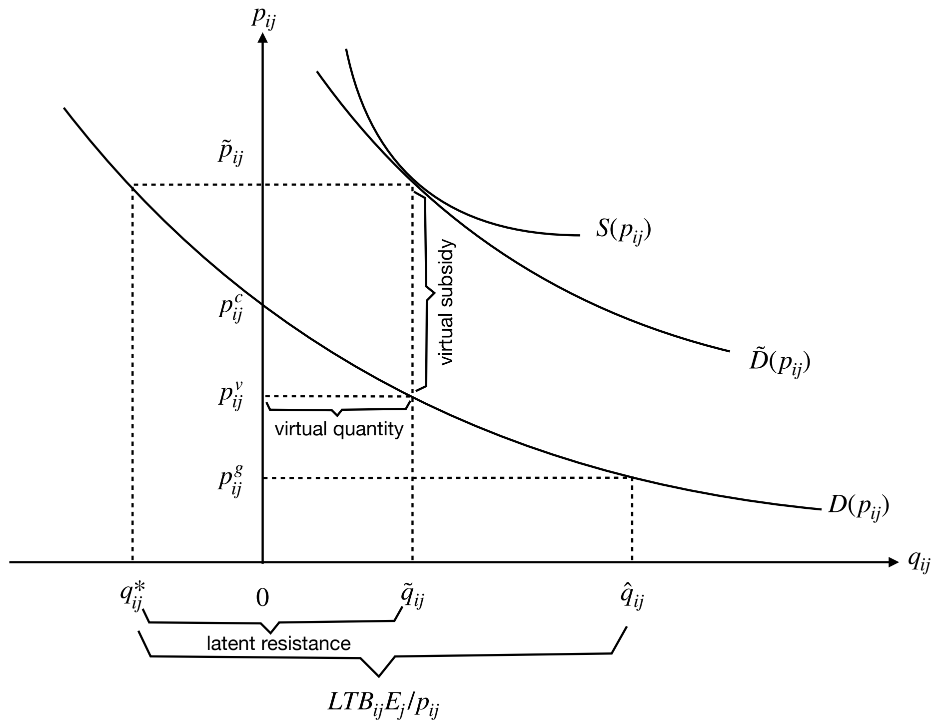

Figure 3: Latent Trade (q^*_{ij})

$D(p_{ij})$ of p_{ij} by equation (9), i.e.,[37]

$$p_{ij}(z)q_{ij}(z)/e_j = \alpha_i - \gamma\beta_i \ln(\mu_i w_i t_{ij}/\bar{p}_j) + \phi_i \ln r_j + \gamma\beta_i \ln z. \tag{35}$$

The break-even-condition for good z is determined by the quantity $q_{ij}(z)$ at which average cost equals price:

$$p_{ij}(z) = w_i t_{ij}/z + F_{ij}/q_{ij}(z). \tag{36}$$

Denote the break-even quantity as $S(p_{ij})$. Figure 3 plots $D(p_{ij})$ against $S(p_{ij})$. p^c_{ij} is the choke price. Since $D(p_{ij})$ for the firm with the highest productivity draw z is everywhere below the break-even condition supply $S(p_{ij})$, no trade occurs. A hypothetical larger market $\widetilde{D}(p_{ij})$ for the highest productivity firm is tangent to the break-even-condition supply curve and generates the minimal level of quantity demanded $\tilde{q}_{ij}$ that initiates trade.

One way to induce the buyer to consume the break-even quantity $\tilde{q}_{ij}$ is to offer a

[37]Note z is the productivity of firm z. Firms from the same origins charge the same markup before drawing productivities.

buyer's price p^v_{ij}, the virtual price.[38] Trade occurs with a subsidy to the buyer equal to $\tilde{p}_{ij} - p^v_{ij}$, the virtual subsidy. An alternative hypothetical way to induce trade is central to this paper. Endow the buyer with the hypothetical quantity equal to $\tilde{q}_{ij} - q^*_{ij}$ (also equal to $\tilde{q}_{ij} + |q^*_{ij}|$). We use this distance from the negative value to the break-even demand to measure how far from break-even is the implied demand, i.e., how far from occurring is the trade. We term this distance latent resistance. In the negative region, the consumer would hypothetically sell the product if she or he has inventory. If the consumer owned the full amount $\tilde{q}_{ij} - q^*_{ij}$ to enable consumption $\tilde{q}_{ij}$, the amount $|q^*_{ij}|$ is sold in the world market at price $\tilde{p}_{ij}$ and the remainder is consumed in the amount $\tilde{q}_{ij}$. The latent resistance $\tilde{q}_{ij} - q^*_{ij}$ is welfare equivalent to the virtual subsidy $\tilde{p}_{ij} - p^v_{ij}$.[39] One plausible way to make the virtual variables actual is as follows. The government buys the amount $\tilde{q}_{ij} - q^*_{ij}$ from the world market at the break-even price. It resells the amount $|q^*_{ij}|$ on the world market at that price, while sells the amount $\tilde{q}_{ij}$ on the domestic market at the virtual price p^v_{ij}. The net loss is $(\tilde{p}_{ij} - p^v_{ij})\tilde{q}_{ij}$, just as in the virtual subsidy case where the virtual subsidy is implemented.

The final step to our application is based on hypothetical frictionless trade. p^g_{ij} is the factory gate price and $\hat{q}_{ij}$ is the frictionless level quantity when all trade costs are zero. The distance from the (negative) quantity q^*_{ij} associated with the break-even-price to the quantity $\hat{q}_{ij}$ for the frictionless price is the latent quantity bias. Since the trade share is our econometric variable of interest, we further define *Latent Trade Bias* in terms of the expenditure share of the latent quantity bias of the product. Specifically,

$$LTB_{ij}(z) = p_{ij}(z)(\hat{q}_{ij}(z) - q^*_{ij}(z))/E_j, \tag{37}$$

where $q^*_{ij}(z)$, the latent value of quantity demand, is negative. We use this full distance to measure how far from frictionless is the implied demand, i.e., how far from the maximum is the trade of product z. This trade bias definition has the advantage of applying equally to positive trade flows, for which predicted latent trade $q_{ij}(z)^*$ in equation (37) is replaced by the predicted positive value of trade. LTB captures the effects of trade costs, as well as the effects of price elasticity $\gamma\beta_i$ and income elasticity ϕ_i.

[38] The virtual price developed by Neary and Roberts (1980) is the price that would induce an initially unconstrained consumer to demand the level of a good when under quantity control (rationing).

[39] Virtual quantity in the literature, e.g., Neary (1985) and Squires (2016), is the quantity of a good that the initially quantity-constrained consumer would demand once unconstrained, given that quantity control's market or accounting price. It is $\tilde{q}_{ij}$ on the diagram. Latent resistance in our paper is distinct.

5.2 Latent Trade Bias Decomposition

This section quantitatively projects the latent trade bias associated with zeros and performs a variance decomposition to measure the extent to which zero trade flows are explained by variable cost, fixed cost, and income effect respectively.[40]

Equation (37) implies that the latent trade bias of a product could be expressed as the difference between the frictionless ($p_{ij}(z)\hat{q}_{ij}(z)/E_j$) and the latent expenditure shares ($p_{ij}(z)q^*_{ij}(z)/E_j$). Using the estimated model we measure the aggregate latent trade bias (LTB) as

$$LTB_{ij} \equiv \frac{Y_i}{Y}/N_i - S_{ij}/N_i, \tag{38}$$

where S_{ij} is the latent trade share when the actual trade share is zero, i.e., the latent value of trade share in the Tobit regression. The LTB can be predicted by the AI gravity equation (20) with all the gravity parameters estimated by the Tobit regression in equation (32), i.e.

$$\widehat{LTB}_{ij} = \frac{Y_i}{Y}/N_i - \hat{S}_{ij}/N_i. \tag{39}$$

An advantage of the AI gravity equation (20) is that the LTB can be decomposed into three effects

$$\widehat{LTB}_{ij} = \underbrace{\widehat{\gamma\beta}_i' \ln(\frac{t_{ij}}{\hat{\Pi}_i \hat{P}_j})}_{X^t_{ij}} + \underbrace{\hat{\lambda}_i'(f_{ij} - \hat{\Psi}_i)}_{X^f_{ij}} \underbrace{-\hat{\phi}_i' \ln(r_j/\hat{R})}_{X^r_{ij}}, \tag{40}$$

where components X^t_{ij}, X^f_{ij}, and X^r_{ij} are the effects of variable cost, fixed cost, and income. All of them can be computed with the parameters estimated. Then we can decompose the LTB variation across country pairs into three margins by the regression method following the literature.[41] Specifically, we regress each component in equation (40) on the LTB and estimate the simultaneous equations

$$X^t_{ij} = \eta_t \widehat{LTB}_{ij} + \epsilon^t_{ij}, \tag{41}$$

$$X^f_{ij} = \eta_f \widehat{LTB}_{ij} + \epsilon^f_{ij}, \tag{42}$$

$$X^r_{ij} = \eta_r \widehat{LTB}_{ij} + \epsilon^r_{ij}, \tag{43}$$

[40] We also add a complementary analysis of how decreases in trade costs raise the chance of trade relationships with the reduced-form Tobit estimates (see Appendix Section C).

[41] See Eaton et al. (2004), Hottman et al. (2016), and Bernard et al. (2019).

with the constraint

$$\eta_t + \eta_f + \eta_r = 1. \tag{44}$$

By the properties of OLS, the coefficients η_t, η_f, and η_r provide us with a measure of how much of the variation in the LTB can be attributed to the effect of variable cost, fixed cost, and income, respectively. This helps us to identify which of the components is the more important one to cause non-partner relationships. Replacing the aggregate LTB and its three components with the corresponding sectoral variables, we can determine the variance decomposition for each sector.

The results are reported in Table 4. Row (1) shows the LTB decomposition for the aggregate trade. Variable cost (distance) explains 53%, fixed cost (entry cost) explains 24%, and income effect explains 23% of the zero flows. We report the results by sectors in row (2)-(26). The coefficients in all sectors are significantly positive and between zero and one. On average, variable cost explains 52%, Fixed cost explains 24%, and income effect explains 24% of the zero flows.

We find that the variable cost effect is larger than both fixed cost effect and income effect for all sectors except machines. Variable cost is strongest in affecting zeros in the other chemical, tobacco and petroleum sectors, and is weakest in the machine, rubber, and chemical sectors. Fixed cost impedes the occurrence of trade most in the iron steel and textile sectors, and least in the apparel and other chemical sectors. The income effect is the strongest in affecting zeros in the machinery and rubber sectors, and is weakest in the iron steel and non-ferrous metal sectors. The possible reason is that products in the former sectors are mainly exported from rich countries (e.g., machinery from Japan) and the zero flows are usually by poor importers. In contrast, the products in the latter sectors are produced by countries with all income levels and thus the income effect is limited for the zero flows.

6 Counterfactuals

The extensive margin effects of export promoting counterfactual reductions of trade costs are measured by the proportions of zeros that turn positive.[42] There are two sets of promotion policies. One is proportional to the export volume and acts as a negative variable cost, e.g., subsidy, tax and financial benefits, duty drawback, export insurance, and ex-

[42]We focus on the extensive margin change with the AIDS structure. See Novy (2013) for discussion on the intensive margin changes with the translog gravity.

Table 4: Latent Trade Bias Decomposition

Latent trade bias		Distance	Entry cost	Income
(1)	Aggregate	0.533***	0.237***	0.230***
		(0.00)	(0.00)	(0.00)
(2)	OthChem	0.641***	0.182***	0.177***
		(0.00)	(0.00)	(0.00)
(3)	Tobacco	0.634***	0.196***	0.170***
		(0.00)	(0.00)	(0.00)
(4)	Petroleum	0.615***	0.218***	0.167***
		(0.00)	(0.00)	(0.00)
(5)	Footwear	0.595***	0.215***	0.190***
		(0.00)	(0.00)	(0.00)
(6)	NonMetal	0.581***	0.225***	0.194***
		(0.00)	(0.00)	(0.00)
(7)	Beverages	0.577***	0.237***	0.186***
		(0.00)	(0.00)	(0.00)
(8)	Paper	0.576***	0.191***	0.233***
		(0.00)	(0.00)	(0.00)
(9)	Plastic	0.561***	0.234***	0.205***
		(0.00)	(0.00)	(0.00)
(10)	Wood	0.553***	0.235***	0.212***
		(0.00)	(0.00)	(0.00)
(11)	Apparel	0.542***	0.176***	0.282***
		(0.00)	(0.00)	(0.00)
(12)	Food	0.540***	0.244***	0.216***
		(0.00)	(0.00)	(0.00)
(13)	Textiles	0.519***	0.312***	0.169***
		(0.00)	(0.00)	(0.00)
(14)	Furniture	0.512***	0.247***	0.241***
		(0.00)	(0.00)	(0.00)
(15)	Printing	0.503***	0.262***	0.235***
		(0.00)	(0.00)	(0.00)
(16)	IronSteel	0.501***	0.335***	0.163***
		(0.00)	(0.00)	(0.00)
(17)	Leather	0.500***	0.210***	0.291***
		(0.00)	(0.00)	(0.00)
(18)	ProfSci	0.496***	0.261***	0.243***
		(0.00)	(0.00)	(0.00)
(19)	Transport	0.491***	0.253***	0.256***
		(0.00)	(0.00)	(0.01)
(20)	NfMetals	0.475***	0.362***	0.163***
		(0.00)	(0.01)	(0.00)
(21)	MetalProd	0.462***	0.202***	0.336***
		(0.00)	(0.00)	(0.00)
(22)	Electrics	0.462***	0.263***	0.276***
		(0.00)	(0.00)	(0.00)
(23)	Glass	0.450***	0.217***	0.333***
		(0.00)	(0.00)	(0.01)
(24)	IndChem	0.439***	0.263***	0.298***
		(0.00)	(0.00)	(0.00)
(25)	Rubber	0.430***	0.199***	0.371***
		(0.00)	(0.00)	(0.00)
(26)	Machines	0.375***	0.185***	0.440***
		(0.00)	(0.00)	(0.01)
	Mean	.521	.237	.242
	St. d.	.067	.046	.072

Notes: Table reports the latent trade bias decomposition by estimating equation system (41)-(43) with constraint (44). Robust standard errors in parentheses. Significance * .10, ** .05, *** .01.

change rate management.[43] The other set works as a negative fixed cost, e.g., providing information, facilitating links, helping with licensing and regulation requirements, and negotiating bilateral fair treatment in the application of regulations. The estimated model permits measurement of the effects of the two types of promotion policies on zero trade flows.

First of all, we calculate the latent values of the trade shares with zero flows by the AI gravity equation (20), i.e.,

$$\widehat{S}_{ij}/N_i = \frac{Y_i}{Y}/N_i - \widehat{\gamma\beta}_i' \ln(\frac{t_{ij}}{\hat{\Pi}_i \hat{P}_j}) - \hat{\lambda}_i'(f_{ij} - \hat{\Psi}_i) + \hat{\phi}_i' \ln(r_j/\hat{R}), \tag{45}$$

and then check the signs of those values. If a latent value is negative, the corresponding country pair is predicted as a zero relationship. The majority of the zero relationships are successfully predicted by our model (See Appendix Figure B.5).

In addition, the latent trade measured by the predicted latent value of trade share implies how far the current relationship is from trade. For example, The U.K. does not export tobacco to Lithuania, but the absolute value of the latent trade is much smaller than to other markets, suggesting that the U.K.'s potential tobacco export to Lithuania is closer becoming actual than with other potential partners (See Appendix Figure B.6 for more examples).

Now we turn to our first question, namely, what proportion of zeros turn positive if we reduce the bilateral cost by 10%, 50%, and 100%, respectively? The answer to this question is important because it tells us the effectiveness of the promotion policy, i.e., the probability of building a new relationship given a country pair not trading with each other yet. Specifically, for any zero flow, we calculate the bilateral cost direct effect as well as its indirect effect(s) through the multilateral resistance(s). According to equations (21) and (23), when country i reduces trade cost to partner j by $\Delta \ln t$, $\ln \Pi_i$ decreases by $(E_j/Y)\Delta \ln t$, and $\ln P_j$ decreases by $N_i\beta_i(1 - E_j/Y)\Delta \ln t$. [44] Then we predict the new latent value of the trade share of that country pair using the AI gravity equation (20). If the predicted latent share becomes positive, the country pair switches to trade (zero-to-one transition). If the predicted latent share remains negative, the flow remains zero.

Table 5 reports the proportions of zero to positive trade flow transitions for all sectors. All numbers are positive, which implies cutting trade cost decreases the number of zeros in sectoral trade. On average, zeros in sectoral trade decrease by 80% due to variable trade

[43] Most of this set of policies are not permissible under WTO rules with some exceptions, e.g., improving the transportation infrastructure to reduce freight costs or managing exchange rates.

[44] The indirect effects are usually limited because the weights on the bilateral costs, the importer's GDP shares, are usually very small. See equations (21) and (23).

Table 5: Zero-to-One Transitions from Reducing Bilateral Costs

		reducing VC by			reducing FC by		
		10%	50%	100%	10%	50%	100%
(1)	Footwear	0.78	0.99	1.00	0.29	0.31	0.36
(2)	OthChem	0.76	0.98	0.99	0.25	0.27	0.35
(3)	Petroleum	0.78	0.98	0.98	0.33	0.35	0.42
(4)	NonMetal	0.50	0.81	0.96	0.15	0.17	0.21
(5)	Food	0.42	0.78	0.95	0.11	0.14	0.22
(6)	ProfSci	0.55	0.89	0.95	0.19	0.24	0.37
(7)	Tobacco	0.61	0.84	0.90	0.24	0.26	0.30
(8)	Electrics	0.61	0.83	0.86	0.26	0.28	0.35
(9)	Printing	0.49	0.81	0.86	0.16	0.18	0.37
(10)	Textiles	0.31	0.69	0.85	0.10	0.12	0.25
(11)	MetalProd	0.57	0.76	0.78	0.36	0.39	0.42
(12)	Wood	0.45	0.69	0.78	0.15	0.19	0.25
(13)	Machines	0.49	0.69	0.78	0.36	0.43	0.55
(14)	Rubber	0.54	0.73	0.75	0.33	0.36	0.40
(15)	Paper	0.51	0.70	0.74	0.19	0.22	0.27
(16)	IronSteel	0.39	0.69	0.74	0.12	0.15	0.25
(17)	Transport	0.42	0.63	0.70	0.20	0.26	0.41
(18)	Beverages	0.43	0.65	0.70	0.13	0.16	0.21
(19)	IndChem	0.36	0.59	0.69	0.18	0.24	0.36
(20)	Plastic	0.40	0.65	0.69	0.14	0.17	0.25
(21)	Glass	0.40	0.60	0.67	0.24	0.28	0.35
(22)	Leather	0.44	0.61	0.66	0.25	0.29	0.37
(23)	NfMetals	0.36	0.58	0.65	0.15	0.18	0.31
(24)	Apparel	0.42	0.60	0.65	0.24	0.30	0.39
(25)	Furniture	0.40	0.58	0.64	0.18	0.24	0.33
	Mean	0.50	0.73	0.80	0.21	0.25	0.33
	St. d.	0.13	0.13	0.12	0.08	0.08	0.08

Notes: Table reports the decrease (%) in number of zeros if bilateral trade costs are reduced.

cost (VC) elimination, while by 33% only due to fixed trade cost (FC) elimination. Similar patterns are found for 10% and 50% trade cost cut. The greater the trade cost cut is, the more zero-to-one transitions we get. Furthermore, the return in terms of building new trading partners is increasing faster for VC cut than FC cut. Comparison of the results for 10%, 50%, and 100% shows that the marginal return of VC cut is decreasing. Lastly, eliminating VC reduces the trade zeros most in footwear and other chemical sectors, while least in furniture and apparel sectors. Eliminating FC reduces the trade zeros most in machinery, metal and petroleum sectors, while least in the beverage and non-metal sectors. But the effects of FC cut are less dispersed than those of VC cut. More importantly, the decreases in zero trade frequency due to VC cut are larger than due to FC cut for all sectors, implying that variable cost is more important than fixed cost in trade policy adjustments aiming to encourage the occurrence of trade.

There are different effects across exporters with different trade (price) elasticities. Intuitively, rich exporters export more inelastic products and thus are less affected by VC cut, while poor exporters increase their (latent) trade shares a lot. Specifically, we divide all exporters into two groups in terms of their GDP per capita and check the difference across groups. Table 6 reports the zero-to-one transitions resulting from reducing bilateral variable costs by 10%. The first and the last three columns outline the transitions for poorer and richer exporters, respectively. On average, a poor exporter has 33 non-partners out of 74. A rich exporter has 11 non-partners out of 74.[45] The effect of a VC (FC) cut is much larger for poor exporters than for rich exporters. The reason is that the demand is more sensitive to the price change of price-elastic products produced by poor exporters and thus the effect of VC (FC) cut for poor exporters is stronger.

Individual cases of export promotion on the extensive margin are exemplified by our headline case of Ethiopia's potential export of leather goods.[46] The 10% cut in the variable (fixed) cost produces 39 (21) new markets. The new partners are countries with middle to high per capita incomes, e.g., Norway and Poland in Europe, and Canada and Mexico in North America (See Table 7). For more context, The leather sector is explored in bilateral detail as an example in Appendix Figure B.7-B.8.

Now we turn to our second question, which is: what proportion of zeros turn positive if exporters unilaterally reduce trade cost by 10%, 50%, and 100%, respectively? The answer to this question is important because it indicates the effectiveness of the unilateral

[45]There are 75 countries in our sample and thus each exporter has 74 partners at most.

[46]Ethiopia in 2006 enjoyed robust GDP and trade growth in excess of 10%. Its external trade goes through the important port of neighbor Djibouti. Ethiopia was at peace with neighboring Eritrea but in conflict with neighboring Somalia and also suffered from civil conflict internally. Its robust trade and GDP growth suggest no effect of conflict on the extensive margin of trade.

Table 6: Zero-to-One Transitions with 10% Decrease in Bilateral Costs: by Income Groups

		poor exporter			rich exporter		
		# of zeros	reducing VC	reducing FC	# of zeros	reducing VC	reducing FC
(1)	Machines	21	0.71	0.53	3	0.02	0.00
(2)	Electrics	21	0.85	0.38	3	0.06	0.00
(3)	Textiles	21	0.52	0.13	6	0.11	0.07
(4)	Food	22	0.74	0.19	6	0.05	0.02
(5)	MetalProd	23	0.92	0.59	5	0.03	0.00
(6)	Apparel	24	0.81	0.46	9	0.02	0.01
(7)	OthChem	27	0.89	0.22	5	0.58	0.29
(8)	Transport	28	0.69	0.34	6	0.02	0.00
(9)	ProfSci	29	0.72	0.22	5	0.30	0.15
(10)	Plastic	29	0.71	0.25	6	0.03	0.01
(11)	Printing	29	0.64	0.15	6	0.27	0.17
(12)	IndChem	30	0.64	0.32	7	0.04	0.02
(13)	Leather	34	0.81	0.47	13	0.05	0.02
(14)	Paper	35	0.89	0.34	8	0.08	0.02
(15)	Rubber	37	0.90	0.57	8	0.07	0.03
(16)	Footwear	38	0.83	0.24	18	0.72	0.33
(17)	Glass	39	0.75	0.44	11	0.05	0.02
(18)	Furniture	39	0.75	0.35	19	0.05	0.02
(19)	IronSteel	39	0.63	0.18	13	0.14	0.07
(20)	NfMetals	40	0.64	0.25	14	0.08	0.04
(21)	NonMetal	40	0.80	0.23	13	0.20	0.07
(22)	Wood	40	0.82	0.30	15	0.09	0.01
(23)	Beverages	41	0.77	0.23	14	0.09	0.03
(24)	Petroleum	49	0.84	0.20	21	0.72	0.45
(25)	Tobacco	60	0.89	0.33	40	0.34	0.15
	Mean	33	0.77	0.32	11	0.17	0.08
	St. d.	10	0.10	0.13	8	0.21	0.12

Notes: Table reports the decrease (%) in number of zeros of different types of exporters if bilateral trade costs are reduced by 10%.

Table 7: Ethiopia's New Markets of Leather Export with Trade Cost Reductions

Ethiopia's new markets with 10% cut in variable cost	fixed cost
Albania	Armenia
Armenia	Austria
Austria	Brazil
Azerbaijan	Bulgaria
Brazil	Canada
Bulgaria	Chile
Canada	Jordan
Chile	Kazakstan
Colombia	Kyrgyzstan
Ecuador	Madagascar
Estonia	Mexico
Iceland	Moldova
Ireland	Mongolia
Jordan	New Zealand
Kazakstan	Niger
Kyrgyzstan	Norway
Latvia	Poland
Lithuania	Portugal
Macedonia	Tanzania
Madagascar	Tunisia
Mexico	Yemen
Moldova	
Mongolia	
Morocco	
New Zealand	
Niger	
Nigeria	
Norway	
Peru	
Poland	
Portugal	
Slovenia	
Sri Lanka	
Tajikistan	
Tanzania	
Tunisia	
Uruguay	
Viet Nam	
Yemen	

Notes: Table reports Ethiopia's new markets of leather export with trade cost reductions.

Table 8: Zero-to-One Transitions from Reducing Unilateral Costs

		reducing VC by			reducing FC by		
		10%	50%	100%	10%	50%	100%
(1)	Footwear	0.29	0.34	0.55	0.29	0.31	0.34
(2)	Petroleum	0.33	0.34	0.46	0.33	0.35	0.41
(3)	MetalProd	0.36	0.40	0.46	0.36	0.39	0.42
(4)	Electrics	0.26	0.33	0.44	0.26	0.28	0.35
(5)	OthChem	0.25	0.27	0.43	0.25	0.27	0.34
(6)	Machines	0.34	0.37	0.39	0.36	0.43	0.54
(7)	Rubber	0.33	0.35	0.37	0.33	0.36	0.40
(8)	Tobacco	0.24	0.25	0.33	0.24	0.26	0.29
(9)	Leather	0.24	0.28	0.31	0.25	0.28	0.35
(10)	Apparel	0.24	0.28	0.31	0.24	0.30	0.38
(11)	Paper	0.19	0.23	0.30	0.19	0.22	0.27
(12)	Glass	0.23	0.25	0.26	0.23	0.28	0.34
(13)	Furniture	0.18	0.21	0.26	0.18	0.24	0.33
(14)	Transport	0.20	0.24	0.26	0.20	0.26	0.40
(15)	Wood	0.14	0.17	0.25	0.15	0.18	0.25
(16)	Beverages	0.12	0.14	0.25	0.13	0.15	0.20
(17)	Food	0.12	0.12	0.22	0.11	0.13	0.21
(18)	NonMetal	0.14	0.14	0.21	0.15	0.17	0.20
(19)	IndChem	0.18	0.19	0.21	0.18	0.23	0.35
(20)	Plastic	0.13	0.15	0.19	0.14	0.17	0.25
(21)	NfMetals	0.14	0.17	0.19	0.15	0.18	0.30
(22)	Printing	0.15	0.14	0.19	0.16	0.18	0.34
(23)	ProfSci	0.19	0.18	0.18	0.19	0.24	0.35
(24)	IronSteel	0.12	0.12	0.16	0.12	0.15	0.23
(25)	Textiles	0.10	0.09	0.12	0.10	0.12	0.21
	Mean	0.21	0.23	0.29	0.21	0.24	0.32
	St. d.	0.08	0.09	0.11	0.08	0.08	0.08

Notes: Table reports the decrease (%) in number of zeros if unilateral trade costs are reduced.

promotion policy, i.e., the probability of building new relationships given an exporter. Appendix Table B.2 reports the number of non-partners for each exporter in each sector. Specifically, for any zero flow, we calculate the bilateral cost direct effect as well as its indirect effect(s) through the multilateral resistance(s). According to equations (21) and (23), when country i reduces trade cost to all its partners by $\Delta \ln t$, $\ln \Pi_i$ decreases by $\Delta \ln t$ too, and $\ln P_j$ does not change. The indirect effects are also important because multilateral resistances change at the same speed as trade costs do. We predict the new latent value of any trade share of that exporter using the AI gravity equation (20). If the predicted latent share becomes positive, the destination country becomes a trading partner (a zero-to-one transition). If the predicted latent share remains negative, the flow remains zero.

The results are reported in Table 8. On average, zeros in sectoral trade decrease by 29% due to VC elimination, and 32% due to FC elimination. No differences between variable and fixed cost reductions are found in the case of a 10% cut, and little difference is found for a 50% or a 100% cut. Furthermore, the return in terms of building new trading partners is increasing slowly in the case of both VC cut and FC cut. Lastly, cutting VC unilaterally reduces the trade zeros most in the footwear, metal and petroleum sectors, while least in the textile and iron steel sectors. Cutting FC unilaterally reduces the trade zeros most in the machinery, metal and petroleum sectors, while least in the beverage, food and textile sectors. The dispersion of the effects of the VC cuts is larger than that of the FC cuts.

7 Robustness

In this section, we demonstrate the robustness of our baseline estimates in Section 4 to alternative measures of the number of goods in Section 7.1, and to an alternative measure of fixed costs in Section 7.2.

7.1 Alternative Measure of the Number of Goods

Our baseline estimation results are reasonably robust with changes in the particular measure of the number of goods N_i. We replace the extensive margin in the baseline estimation with two alternative variables. The first one is the total number of firms for each country sourced from CEPII, and the second one is the log GDP for each country. We normalize each variable by dividing the sum across all countries to obtain a share measure.

The results, together with our baseline estimates, are reported in Table 9. In column (2), we use the number of firms to replace the extensive margin. The coefficient of distance is significantly negative. The coefficient of the interaction term of distance and exporter

Table 9: Robustness: Alternative Measures of Number of Goods

Import share per firm	(1) N_i =Extensive Margin	(2) N_i =No. of Firms	(3) N_i =ln GDP
Distance	-1.1585***	-0.6438***	-0.5786***
	(0.0255)	(0.0271)	(0.0236)
Distance × Income_ex	0.1279***	0.0467***	0.0412***
	(0.0028)	(0.0029)	(0.0025)
Entry cost	-5.8054***	-2.8016***	-1.2624
	(0.8925)	(0.9317)	(0.8003)
Entry cost × Income_ex	0.5502***	0.2573***	0.1020
	(0.0881)	(0.0920)	(0.0791)
Income_im × Income_ex	0.0169	-0.0225	-0.0050
	(0.0214)	(0.0230)	(0.0199)
Internal	2.8290***	7.9230***	7.9496***
	(0.0803)	(0.0851)	(0.0740)
Observations	5625	5625	5625
R-squared	0.5762	0.7358	0.8166

Notes: Table reports the estimates of the AI gravity in equation (32) with alternative measures of number of goods. Estimated exporter- and importer-specific fixed effects are dropped. Robust standard errors in parentheses. Significance * .10, ** .05, *** .01.

income is significantly positive, implying that the distance reduces trade by less for richer exporters. This suggests that there is a significant price elasticity heterogeneity across exporters. Both coefficients are smaller in magnitude than the baseline results in column (1) due to less variation in the number of firms compared to the extensive margin measure. But the price elasticity heterogeneity pattern is consistent. Similar results are obtained when we use log GDP in column (3). The coefficients of entry cost and its interaction term are significant in column (2) but not in column (3). The coefficient of the income interaction term is insignificantly different from zero in the last two regressions. This suggests that there is little income elasticity heterogeneity across exporters for aggregate manufacturing trade. The coefficients of the internal trade dummy are also significant, implying the internal trade share is larger than foreign trade, given all else equal.

7.2 Alternative Measure of Fixed Cost

In this part, we examine another measure for the fixed cost to ensure that the coefficient patterns in our baseline regression do not hinge on a particular measure.

In Table 10, we replace entry cost with entry days & proc which is the sum of the number of days and the number of legal procedures necessary for an entrepreneur to legally

Table 10: Robustness: Alternative Fixed Cost

Import share per firm		Distance	Dist.×Inc_ex ×Inc_ex	Days & proc.	Days & proc. ×Inc_ex	Inc_im×Inc_ex ×Inc_ex	Internal	Obs.
(1)	Aggregate	-1.12***	0.12***	-0.22***	0.03***	0.04*	2.77***	5625
		(0.03)	(0.00)	(0.02)	(0.00)	(0.02)	(0.08)	
(2)	Beverages	-2.35***	0.25***	-0.61***	0.07***	0.11**	3.53***	5625
		(0.06)	(0.01)	(0.06)	(0.01)	(0.05)	(0.18)	
(3)	Furniture	-2.42***	0.25***	-0.83***	0.09***	0.18***	4.30***	5625
		(0.06)	(0.01)	(0.06)	(0.01)	(0.06)	(0.19)	
(4)	Tobacco	-2.64***	0.24***	-0.52***	0.06***	0.13*	0.95***	5625
		(0.08)	(0.01)	(0.09)	(0.01)	(0.08)	(0.25)	
(5)	Petroleum	-2.28***	0.22***	-0.17***	0.02**	-0.02	1.33***	5625
		(0.07)	(0.01)	(0.06)	(0.01)	(0.06)	(0.20)	
(6)	NonMetal	-2.05***	0.21***	-0.29***	0.03***	0.03	3.29***	5625
		(0.06)	(0.01)	(0.05)	(0.01)	(0.05)	(0.18)	
(7)	Leather	-1.68***	0.18***	-0.35***	0.04***	0.13***	1.57***	5625
		(0.05)	(0.01)	(0.05)	(0.01)	(0.05)	(0.16)	
(8)	Plastic	-1.61***	0.17***	-0.19***	0.02***	0.03	2.35***	5625
		(0.04)	(0.00)	(0.04)	(0.00)	(0.04)	(0.13)	
(9)	Food	-1.61***	0.17***	-0.31***	0.04***	0.04	3.66***	5625
		(0.04)	(0.00)	(0.04)	(0.00)	(0.04)	(0.13)	
(10)	NfMetals	-1.55***	0.16***	-0.56***	0.06***	0.09**	1.24***	5625
		(0.04)	(0.00)	(0.04)	(0.01)	(0.04)	(0.13)	
(11)	Glass	-1.38***	0.14***	-0.34***	0.04***	0.13***	2.14***	5625
		(0.04)	(0.00)	(0.04)	(0.00)	(0.04)	(0.13)	
(12)	Wood	-1.37***	0.14***	-0.17***	0.02***	0.03	1.96***	5625
		(0.03)	(0.00)	(0.03)	(0.00)	(0.03)	(0.10)	
(13)	Printing	-1.35***	0.14***	-0.04	0.00	-0.07*	3.77***	5625
		(0.04)	(0.00)	(0.04)	(0.00)	(0.04)	(0.13)	
(14)	Footwear	-1.16***	0.12***	-0.05	0.01	-0.01	1.11***	5625
		(0.04)	(0.00)	(0.03)	(0.00)	(0.03)	(0.11)	
(15)	Paper	-1.08***	0.11***	0.00	0.00	0.02	1.49***	5625
		(0.03)	(0.00)	(0.02)	(0.00)	(0.02)	(0.09)	
(16)	Apparel	-1.07***	0.11***	-0.30***	0.03***	0.08***	1.80***	5625
		(0.02)	(0.00)	(0.02)	(0.00)	(0.02)	(0.08)	
(17)	OthChem	-0.95***	0.10***	-0.09***	0.01***	0.01	1.43***	5625
		(0.02)	(0.00)	(0.02)	(0.00)	(0.02)	(0.07)	
(18)	Transport	-0.98***	0.10***	-0.45***	0.05***	0.10***	1.51***	5625
		(0.02)	(0.00)	(0.02)	(0.00)	(0.02)	(0.07)	
(19)	IronSteel	-0.94***	0.09***	-0.39***	0.04***	0.04	1.64***	5625
		(0.03)	(0.00)	(0.03)	(0.00)	(0.03)	(0.10)	
(20)	ProfSci	-0.81***	0.09***	-0.10***	0.01***	-0.01	1.22***	5625
		(0.03)	(0.00)	(0.03)	(0.00)	(0.03)	(0.10)	
(21)	Textiles	-0.80***	0.08***	-0.42***	0.05***	0.04**	1.57***	5625
		(0.02)	(0.00)	(0.02)	(0.00)	(0.02)	(0.07)	
(22)	Electrics	-0.66***	0.07***	-0.07**	0.01**	0.03	1.30***	5625
		(0.03)	(0.00)	(0.03)	(0.00)	(0.03)	(0.10)	
(23)	IndChem	-0.56***	0.06***	-0.15***	0.02***	0.05**	1.56***	5625
		(0.02)	(0.00)	(0.02)	(0.00)	(0.02)	(0.07)	
(24)	MetalProd	-0.63***	0.06***	-0.00	0.00	0.04**	1.80***	5625
		(0.02)	(0.00)	(0.02)	(0.00)	(0.02)	(0.07)	
(25)	Rubber	-0.64***	0.06***	-0.12***	0.01***	0.09***	1.22***	5625
		(0.03)	(0.00)	(0.03)	(0.00)	(0.03)	(0.09)	
(26)	Machines	-0.53***	0.05***	-0.28***	0.03***	0.10***	0.88***	5625
		(0.02)	(0.00)	(0.02)	(0.00)	(0.02)	(0.07)	

Notes: Table reports the estimates of the sectoral AI gravity in equation (34) with alternative fixed cost. Estimated exporter- and importer-specific fixed effects are dropped. Robust standard errors in parentheses. Significance * .10, ** .05, *** .01.

start operating a business.[47] It is a nonmonetary measure of fixed cost to supplement the entry cost, which is a monetary measure. We take an average of these nonmonetary costs from the exporter and importer sides as the bilateral measure. By construction, entry days & proc. reflects regulation costs that should not depend on a firm's volume of exports to a particular country. The purpose of using the alternative fixed cost variable is to check whether the distance coefficient patterns in Table 3 are driven by the measurement of fixed costs. We find that the coefficients on distance and its interaction with exporter income are very similar to the baseline table. This implies that the result regarding the heterogeneity of the distance elasticity is robust. And the order of the sectoral results is close to the baseline results also, suggesting that the relative degree of the elasticity dispersion among sectors is also robust. The coefficients of entry days & proc. and its interaction term with income are significant for most sectors. The results are robust.

8 Conclusion

This paper applies Almost Ideal Demand System (AIDS) preferences to the firm heterogeneity framework and derives an AI gravity equation that explains zero trade flows theoretically in a tractable form used for estimation. Latent trade inferred from the estimated model is used to measure the distance from observed zeros to trade. Heterogeneous price and income elasticities interact with variable and fixed cost heterogeneity to explain the zeros. Variance decomposition of distance from trade apportions the relative importance of fixed and variable cost variation.

The predicted latent trade value has potentially important policy implications. Trade promotion policies could be targeted toward potential markets on the margin that are much closer to zero. The marginal effect of a fixed cost reduction in turning zero trade to positive is smaller than that of a variable cost reduction, but still significant.

Our empirical results are based on country-level ISIC3 trade flows, but our methods naturally extend to applications using firm-level data to appropriately target export promotion policies and to inform firm entry decisions independent of explicit promotion policies. On the importer side, the estimated model could suggest potential sources of inputs. Disaggregation to more finely delimited sectors will come closer to firm-level activity and present some of the same opportunities.

[47] Helpman et al. (2008) also use the sum of these two measures of fixed costs to obtain sufficient variations.

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Appendix for:
"Latent Exports: Almost Ideal Gravity and Zeros"

A Appendix to Model

A.1 Reservation Prices

Denote M as the maximum number of products in the world. We will allow for a subset of goods to have zero shares. To be precise, suppose that $s(\omega) > 0$ for $\omega = 1, ..., N$, while $s(\omega) = 0$ for $\omega = N+1, ..., M$. Then for the latter goods, we set $s(\omega) = 0$ within the share equation (4), and use these $(M - N)$ equations to solve for the reservation prices $\tilde{p}(\omega)$, $\omega = N+1, ..., M$, in terms of the observed prices $p(\omega)$, $\omega = 1, ..., N$. Then these reservation prices should appear in the expenditure equation (1) for the unavailable goods $\omega = N+1, ..., M$. Specifically,

$$0 = \alpha(\omega) - \gamma\beta(\omega)\ln\tilde{p}(\omega) + \gamma\beta(\omega)\sum_{\omega'=1}^{N}\beta(\omega')\ln p(\omega')$$

$$+\gamma\beta(\omega)\sum_{\omega'=N+1}^{M}\beta(\omega')\ln\tilde{p}(\omega'); \quad \omega = N+1, ..., M. \tag{46}$$

Here we temporarily assume homotheticity for unavailable goods, i.e., $\phi(\omega) = 0$ for the goods $\omega = N+1, ..., M$, following Feenstra (2010).

Denote the sub-index for actively traded goods as $\ln\bar{p}^{+} = \sum_{\omega'=1}^{N}\beta(\omega')\ln p(\omega')$, and the sub-index for inactively traded goods as $\ln\bar{p}^{-} = \sum_{\omega'=N+1}^{M}\beta(\omega')\ln\tilde{p}(\omega')$. Then the third and fourth terms on the right hand side of equation (46) comprise $\gamma\beta(\omega)$ times the full price index $\ln\bar{p} = \ln\bar{p}^{+} + \ln\bar{p}^{-}$; $\forall\omega$. Our procedure is to solve for $\ln\bar{p}^{-}$ from (46). By summing equation (46) over ω, we have

$$0 = \sum_{\omega=N+1}^{M}\alpha(\omega) - \gamma\ln\bar{p}^{-} + \gamma\left(\sum_{\omega=N+1}^{M}\beta(\omega)\right)\ln\bar{p}^{+} + \gamma\left(\sum_{\omega=N+1}^{M}\beta(\omega)\right)\ln\bar{p}^{-}.$$

Then

$$\ln\bar{p}^{-} = \frac{\gamma^{-1}\sum_{\omega=N+1}^{M}\alpha(\omega) + \left(\sum_{\omega=N+1}^{M}\beta(\omega)\right)\ln\bar{p}^{+}}{1 - \sum_{\omega=N+1}^{M}\beta(\omega)}. \tag{47}$$

Substitute the right hand side of (47) into the full price index. The result is

$$\ln \bar{p} = \frac{\ln \bar{p}^{+} + \gamma^{-1} \sum_{\omega=N+1}^{M} \alpha(\omega)}{1 - \sum_{\omega=N+1}^{M} \beta(\omega)}. \tag{48}$$

Equation (53) holds for all destinations j and is basically a j-specific price index effect. So it is presumably absorbed in the regressor with fixed effects for multilateral resistance.

Our additional analytic concern is for counterfactual changes in variable cost and fixed cost and their effect on the price index (53). The experiments we run are exemplified by a scalar $0 < \lambda < 1$ that shrinks all t_{ij} proportionately. Thus a fall in λ lowers t_{ij}. Consider a fall in $\lambda, d\ln\lambda < 0$, a globally applied proportionate decrease in trade costs.

Over some interval there may be no change in N, the extensive margin, hence $\ln \bar{p}$ falls by $d\ln\lambda/[1 - \sum_{\omega=N+1}^{M} \beta(\omega)]$. The more important case for our counterfactual experiments is where N rises as a result of λ falling. It is now convenient to revert to continuous ω, hence sums become integrals. In the numerator of (53), a fall in λ raises N and hence it lowers the second term by $\gamma^{-1}\alpha(N)$. In the first term of the numerator, $\ln \bar{p}^{+}$ increases by $\beta(N)\ln p(N)$. The denominator of (53) changes by $-\beta(N)/[1 - \int_{\omega=N+1}^{M} \beta(\omega)d\omega]^2$. Our procedure is focused on the direct N fixed impact, which intuitively suggests that cutting all VC equiproportionately will keep decreasing $\ln \bar{p}$, hence the direct impact effect may well dominate the variable N effects. As for the variable N effects: the fall in the term $\gamma^{-1}\alpha(N)$ has the same sign as the N fixed impact.

Finally, consider the non-homothetic case $\phi(\omega) \neq 0$ for the goods $\omega = N+1, ..., M$. Following Deaton and Muellbauer (1980), the Stone price index in equation (2) is approximated by prices weighted by observed shares, i.e.,

$$\ln Q = \sum_{\omega=1}^{N} s(\omega) \ln p(\omega) \tag{49}$$

and the summation of the share equation is

$$0 = \sum_{\omega=N+1}^{M} \alpha(\omega) - \gamma \ln \bar{p}^{-} + \gamma \left(\sum_{\omega=N+1}^{M} \beta(\omega) \right) \ln \bar{p}^{+} + \gamma \left(\sum_{\omega=N+1}^{M} \beta(\omega) \right) \ln \bar{p}^{-} \tag{50}$$

$$+ \left(\sum_{\omega=N+1}^{M} \phi(\omega) \right) \ln(e/Q) \tag{51}$$

Then

$$\ln \bar{p}^{-} = \frac{\gamma^{-1} \sum_{\omega=N+1}^{M} \alpha(\omega) + \left(\sum_{\omega=N+1}^{M} \beta(\omega)\right) \ln \bar{p}^{+} + \gamma^{-1} \left(\sum_{\omega=N+1}^{M} \phi(\omega)\right) \ln(e/Q)}{1 - \sum_{\omega=N+1}^{M} \beta(\omega)}. \tag{52}$$

Substitute the right hand side of (52) into the full price index. The result is

$$\ln \bar{p} = \frac{\ln \bar{p}^{+} + \gamma^{-1} \sum_{\omega=N+1}^{M} \alpha(\omega) + \gamma^{-1} \left(\sum_{\omega=N+1}^{M} \phi(\omega)\right) \ln(e/Q)}{1 - \sum_{\omega=N+1}^{M} \beta(\omega)}. \tag{53}$$

The evaluation of our counterfactual changes by adding another ambiguously signed term as N rises. Note that $\phi(\omega)$ is positive for luxury goods and negative for necessary goods. So long as $\phi(N) > 0$ the effect of raising N via income effects acts to raise $\ln \bar{p}$, *cet. par.*. This arises because the incipient reduction in $\ln \bar{p}$ raises real income, hence raises spending on the extensive margin goods and tends to offset the incipient reduction in $\ln \bar{p}$. Continued fall in λ continues to reduce $\ln \bar{p}$ on balance so long as the substitution effect is large enough or the income effect is small enough. With this warning, our procedure in the counterfactual is appropriate.

A.2 Firm Aggregation

Equation (9) and (11) imply

$$
\begin{aligned}
S_{ij} &= N_i \int_{\ln z_{ij}^*}^{H} s_{ij}(a) dG(a) \\
S_{ij}/N_i &= [\alpha_i - \gamma\beta_i \ln(\mu_i w_i t_{ij}/\bar{p}_j) + \phi_i \ln r_j] \int_{\ln z_{ij}^*}^{H} dG(a) + \gamma\beta_i \int_{\ln z_{ij}^*}^{H} a dG(a) \\
&\approx \gamma\beta_i \int_{\ln z_{ij}^*}^{H} a dG(a) \\
&= \gamma\beta_i (H - \ln z_{ij}^*)/\ln H \\
&= (1/\ln H)[\alpha_i - \gamma\beta_i \ln(\mu_i w_i t_{ij}/\bar{p}_j) + \phi_i \ln r_j] \\
&\quad + (H/\ln H)\gamma\beta_i - (1/\ln H)\mu_i/(\mu_i - 1) f_{ij} \\
&= (1/\ln H)\alpha_i + (H/\ln H)\gamma\beta_i \\
&\quad - (1/\ln H)\gamma\beta_i \ln(\mu_i w_i t_{ij}/\bar{p}_j) \\
&\quad - (1/\ln H)\mu_i/(\mu_i - 1) f_{ij} \\
&\quad + (1/\ln H)\phi_i \ln r_j
\end{aligned}
$$

where $\int_{\ln z_{ij}^*}^{H} dG(a) \approx 0$ given only a very small fraction of firms export in every country.

A.3 AI Gravity

Plug equation (14) into equation (19),

$$
\begin{aligned}
(Y_i/Y)/N_i &= \sum_j (E_j/Y)[\alpha_i' - \gamma\beta_i' \ln(\mu_i w_i t_{ij}/\bar{p}_j) - \lambda_i' f_{ij} + \phi_i' \ln r_j] \\
&= [\alpha_i' - \gamma\beta_i' \ln(\mu_i w_i) + \gamma\beta_i' \sum_k N_k \beta_k \ln \mu_k w_k] \\
&\quad - \sum_j (E_j/Y)[\gamma\beta_i'(\ln t_{ij} - \sum_k N_k \beta_k \ln t_{kj}) + \lambda_i' f_{ij} - \phi_i' \ln r_j]
\end{aligned}
$$

Then

$$
\begin{aligned}
S_{ij}/N_i &= [\alpha_i' - \gamma\beta_i' \ln(\mu_i w_i) + \gamma\beta_i' \sum_k N_k \beta_k \ln \mu_k w_k] \\
&\quad - [\gamma\beta_i'(\ln t_{ij} - \sum_k N_k \ln t_{kj}) + \lambda_i' f_{ij} - \phi_i' \ln r_j] \\
&= (Y_i/Y)/N_i + \sum_j (E_j/Y)[\gamma\beta_i'(\ln t_{ij} - \sum_k N_k \beta_k \ln t_{kj}) + \lambda_i' f_{ij} - \phi_i' \ln r_j] \\
&\quad - [\gamma\beta_i'(\ln t_{ij} - \sum_k N_k \beta_k \ln t_{kj}) + \lambda_i' f_{ij} - \phi_i' \ln r_j] \\
&= (Y_i/Y)/N_i \\
&\quad - \gamma\beta_i'[\ln t_{ij} - \sum_j (E_j/Y) \ln t_{ij} - \sum_k N_k \beta_k \ln t_{kj} + \sum_j (E_j/Y) \sum_k N_k \beta_k \ln t_{kj}] \\
&\quad - \lambda_i'[f_{ij} - \sum_j (E_j/Y) f_{ij}] \\
&\quad - \phi_i'[\ln r_j - \sum_j (E_j/Y) r_j]
\end{aligned}
$$

B Appendix to Tables and Figures

Table B.1: Country List by GDP

	ISO	country		ISO	country
1	USA	United States	39	PHL	Philippines
2	JPN	Japan	40	NGA	Nigeria
3	DEU	Germany	41	HUN	Hungary
4	CHN	China	42	UKR	Ukraine
5	GBR	United Kingdom	43	NZL	New Zealand
6	FRA	France	44	PER	Peru
7	ITA	Italy	45	KAZ	Kazakstan
8	CAN	Canada	46	VNM	Viet Nam
9	ESP	Spain	47	MAR	Morocco
10	BRA	Brazil	48	SVK	Slovakia
11	RUS	Russia	49	ECU	Ecuador
12	IND	India	50	SVN	Slovenia
13	KOR	Korea	51	BGR	Bulgaria
14	MEX	Mexico	52	TUN	Tunisia
15	AUS	Australia	53	LTU	Lithuania
16	NLD	Netherlands	54	LKA	Sri Lanka
17	TUR	Turkey	55	KEN	Kenya
18	SWE	Sweden	56	AZE	Azerbaijan
19	CHE	Switzerland	57	LVA	Latvia
20	IDN	Indonesia	58	URY	Uruguay
21	POL	Poland	59	YEM	Yemen
22	AUT	Austria	60	EST	Estonia
23	NOR	Norway	61	ISL	Iceland
24	DNK	Denmark	62	JOR	Jordan
25	ZAF	South Africa	63	ETH	Ethiopia
26	GRC	Greece	64	GHA	Ghana
27	IRL	Ireland	65	TZA	Tanzania
28	FIN	Finland	66	ALB	Albania
29	THA	Thailand	67	GEO	Georgia
30	PRT	Portugal	68	ARM	Armenia
31	HKG	Hong Kong	69	MKD	Macedonia
32	MYS	Malaysia	70	MDG	Madagascar
33	CHL	Chile	71	NER	Niger
34	CZE	Czech	72	MDA	Moldova
35	COL	Colombia	73	TJK	Tajikistan
36	SGP	Singapore	74	KGZ	Kyrgyzstan
37	PAK	Pakistan	75	MNG	Mongolia
38	ROM	Romania			

Notes: Table lists the sample of countries in our paper. The countries are sorted by GDP in descending order.

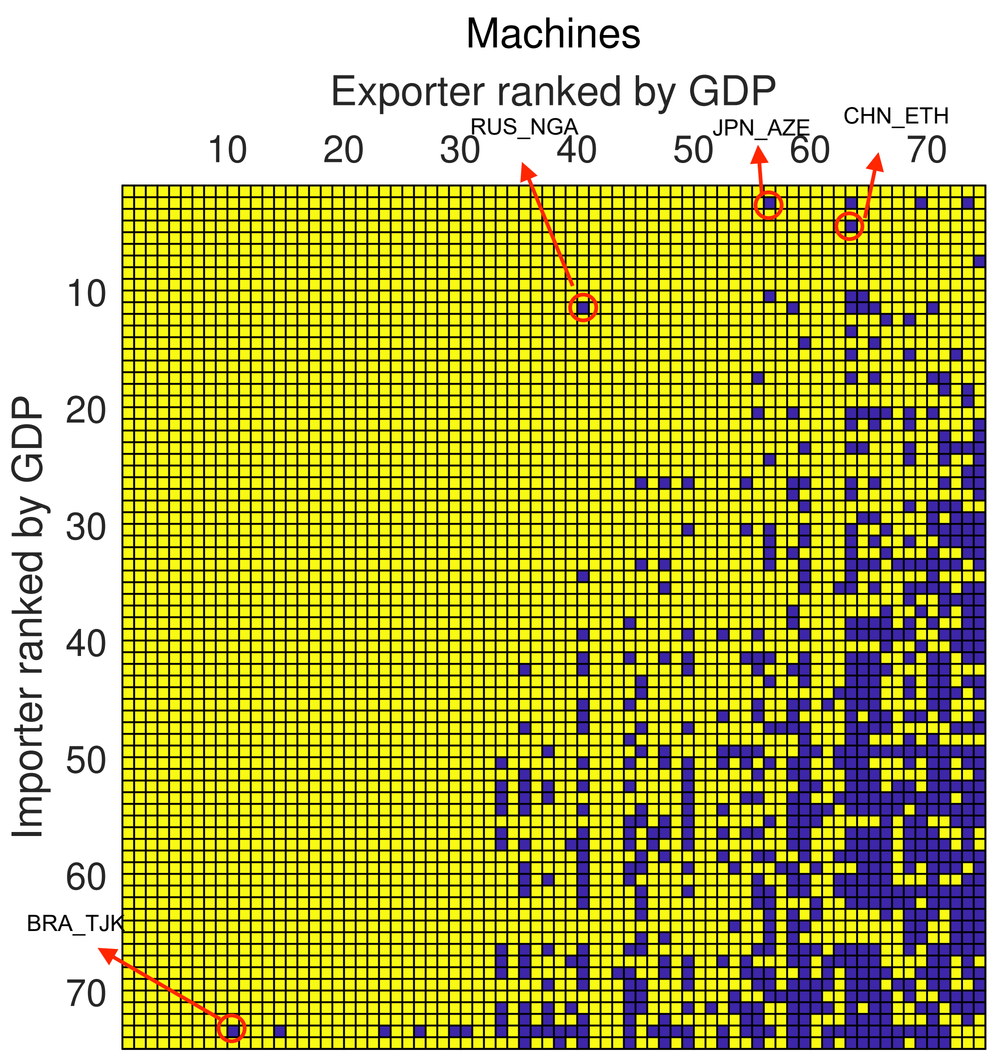

Figure B.1: Zero Trade Flows by Country Pairs: Machines Sector

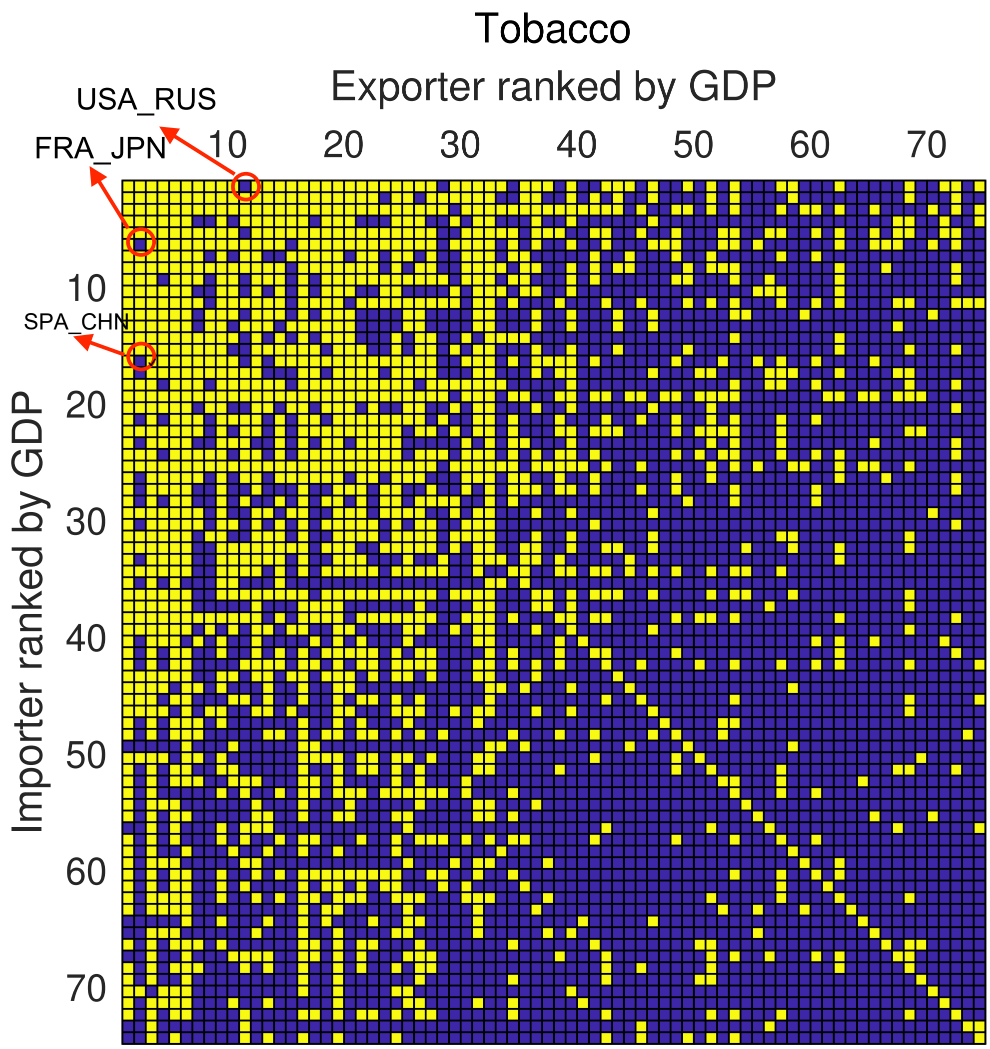

Figure B.2: Zero Trade Flows by Country Pairs: Tobacco Sector

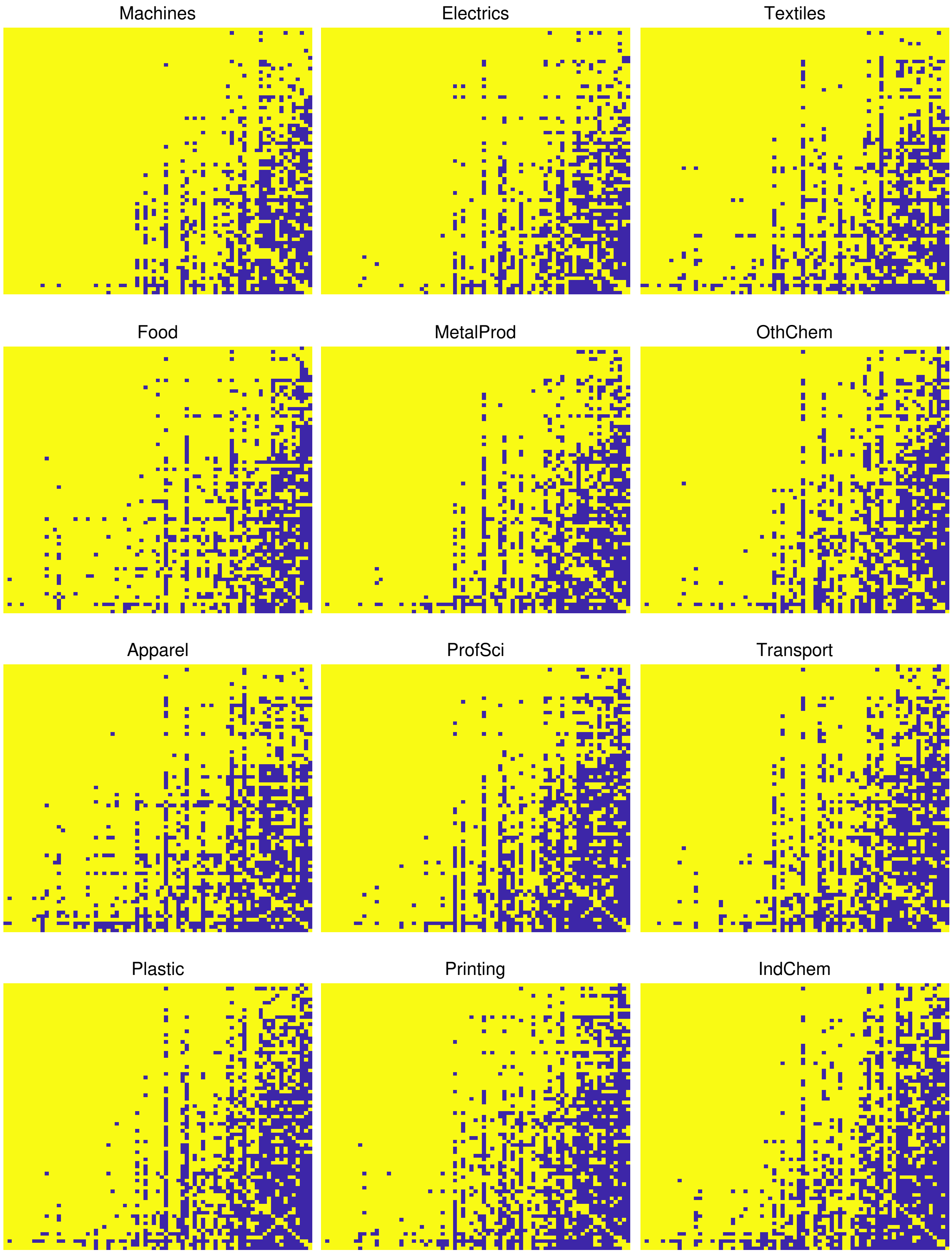

Figure B.3: Zero Trade Flows by Country Pairs: All Other Sectors I

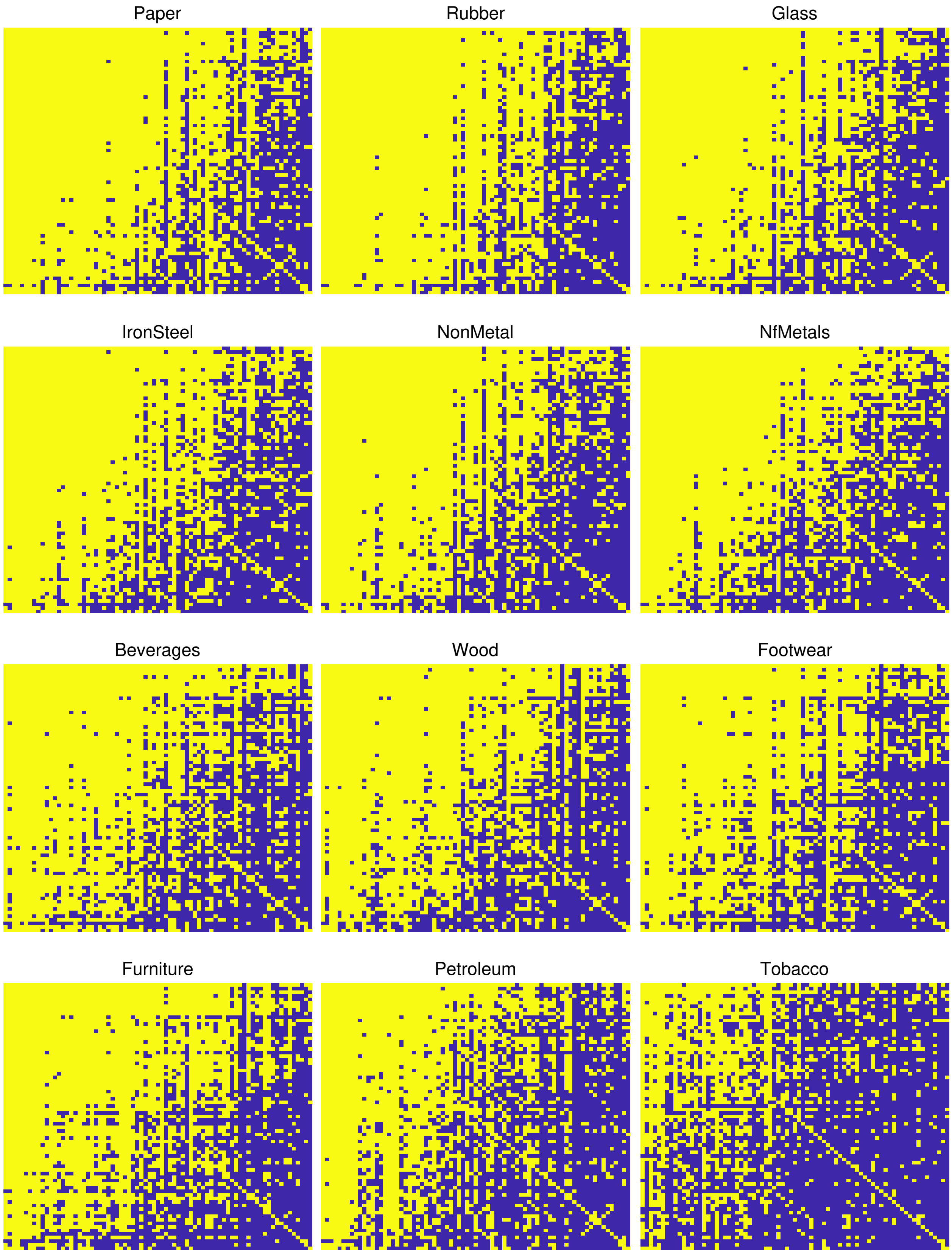

Figure B.4: Zero Trade Flows by Country Pairs: All Other Sectors II

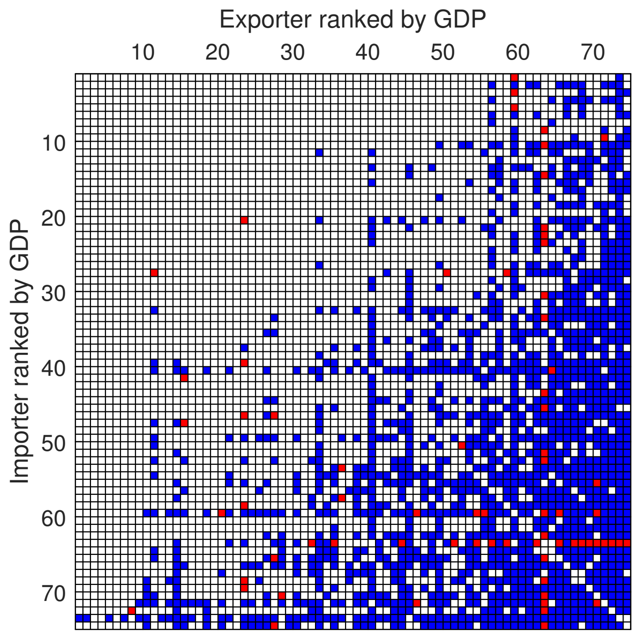

Figure B.5: Zero Flow Prediction: Leather Sector

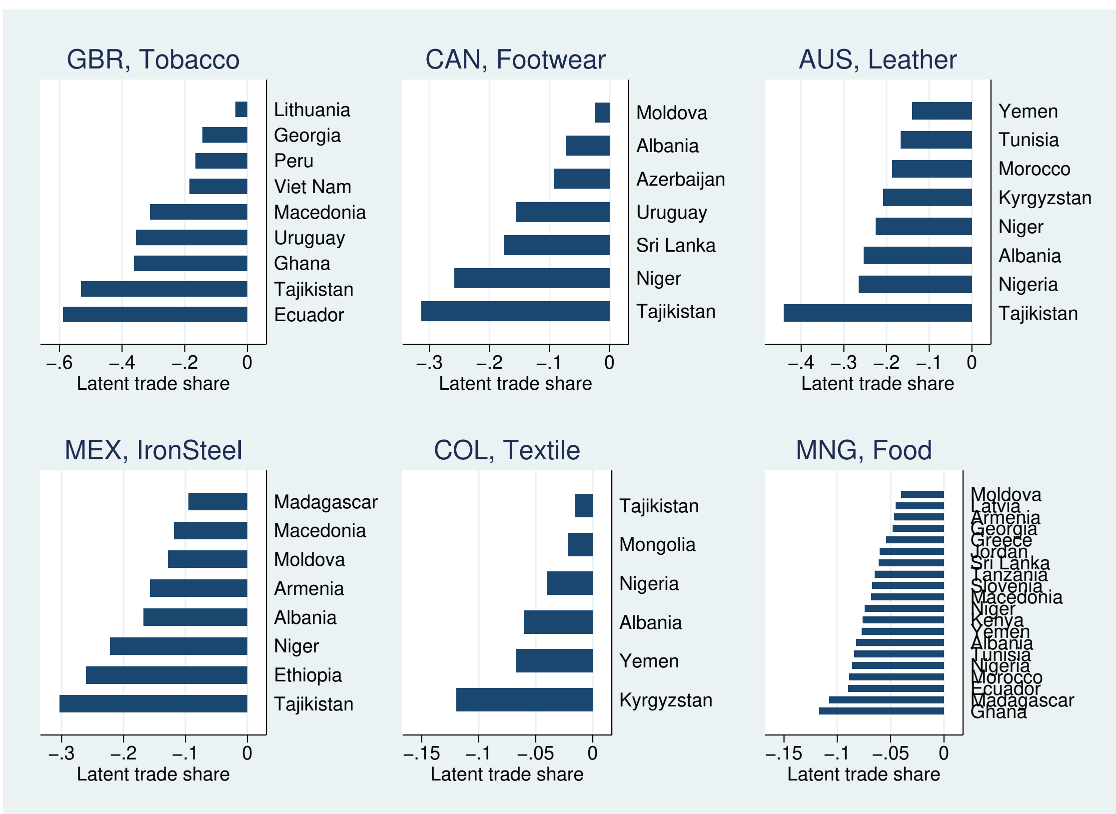

Figure B.6: Latent Trade Examples

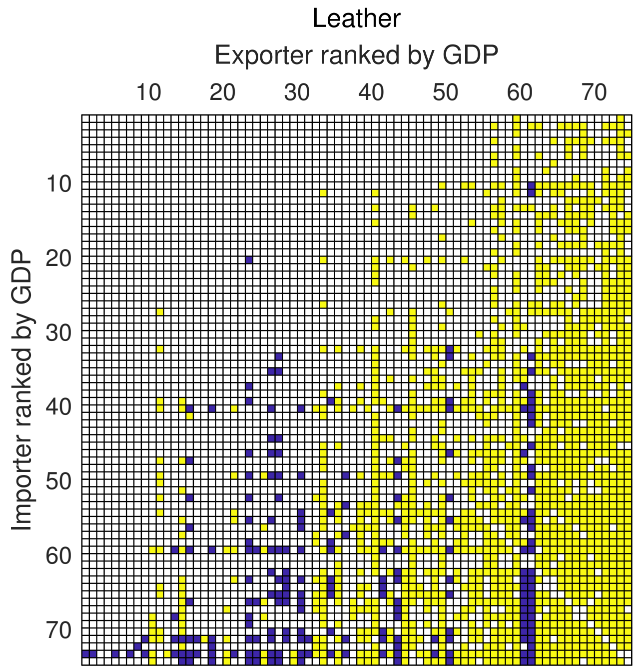

Figure B.7: Zero-to-One Transitions from Removing Bilateral Variable Costs: Leather Sector

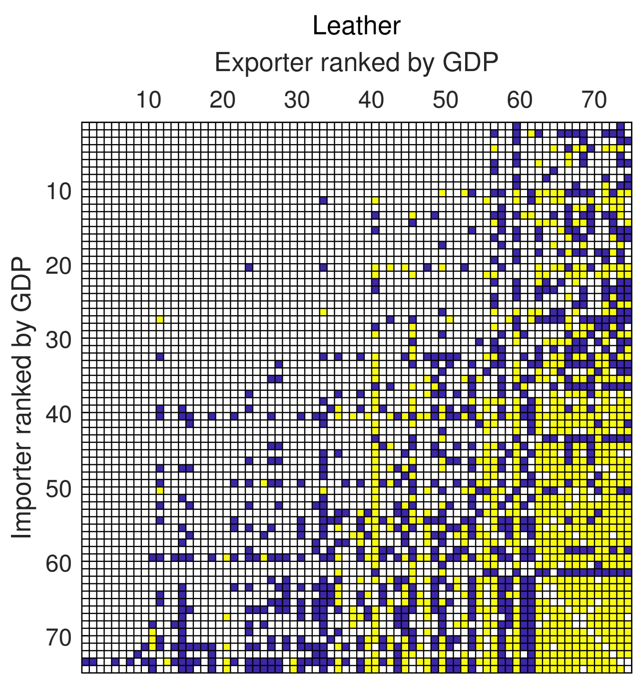

Figure B.8: Zero-to-One Transitions from Removing Bilateral Fixed Costs: Leather Sector

Table B.2: Number of Zero Flows by Exporter and Sector (75 countries)

Exporter	Tobacco	Petroleum	Furniture	Wood	Footwear	Beverages	NonMetal	NfMetals	IronSteel	Glass	Leather	Rubber	Paper	IndChem	Plastic	ProfSci	Printing	Transport	OthChem	Apparel	MetalProd	Food	Textiles	Machines	Electrics	Mean
TJK	72	73	71	73	67	73	70	48	68	72	70	68	72	62	65	63	65	62	66	52	55	62	42	41	46	63
YEM	70	61	72	71	72	69	61	57	64	70	61	65	61	55	54	46	50	41	53	57	40	31	56	39	37	57
NER	70	56	65	69	64	67	61	65	62	64	62	58	54	49	52	47	54	45	52	50	49	48	50	39	31	55
KGZ	65	49	65	67	56	61	60	58	56	69	58	66	57	46	57	52	58	43	49	49	42	49	40	44	39	54
ETH	74	71	58	71	58	60	60	57	65	57	39	62	62	64	52	52	48	54	44	40	45	29	31	50	45	54
MNG	67	62	60	56	53	57	63	66	63	63	48	57	61	62	53	49	48	43	54	31	43	55	27	41	41	53
ARM	50	70	60	62	63	45	50	54	48	55	59	64	53	33	50	43	51	54	46	50	45	47	47	37	42	51
ALB	71	64	58	60	41	62	62	53	57	60	59	56	52	53	51	44	45	44	42	30	37	52	40	30	36	50
AZE	66	48	57	58	63	60	66	54	54	44	49	57	55	44	45	37	36	41	46	54	30	41	33	24	23	47
MDG	69	54	38	53	58	63	47	63	54	59	43	59	46	55	47	51	55	50	37	18	37	34	15	40	34	47
TZA	65	60	34	47	62	32	59	51	54	60	46	65	58	49	47	47	47	42	45	45	34	20	23	41	31	47
NGA	70	53	55	39	53	56	61	51	50	61	48	38	55	46	49	39	37	41	43	42	42	34	42	26	31	46
GHA	71	64	28	20	59	53	59	45	59	53	50	49	57	53	47	50	46	40	35	48	29	22	43	37	32	46
MDA	55	67	60	48	37	32	65	59	54	55	55	62	46	56	39	40	41	44	41	25	44	29	27	27	32	46
MKD	70	53	59	47	41	37	50	54	44	59	48	52	51	45	41	40	39	34	44	26	38	38	26	22	26	43
URY	65	70	63	47	49	36	53	56	51	54	22	49	44	37	36	31	35	39	30	27	35	10	12	33	29	41
KAZ	62	39	55	54	57	51	59	33	14	45	40	47	53	23	42	29	31	32	36	39	27	36	27	18	26	39
JOR	49	72	58	66	60	61	47	43	54	44	52	47	37	12	25	27	28	29	9	13	16	31	18	12	21	37
GEO	65	55	63	44	50	33	52	45	38	43	53	44	39	27	34	27	28	24	17	41	20	32	28	12	15	37
KEN	68	59	28	44	40	40	33	49	50	46	32	54	42	37	34	40	29	26	31	25	28	11	20	23	24	37
ECU	66	55	35	25	52	50	48	46	37	48	38	42	39	31	26	29	38	33	27	34	27	8	30	22	26	36
ISL	73	31	61	53	56	52	52	45	41	39	36	34	41	32	20	21	20	28	17	31	20	12	25	9	16	35
PER	67	55	35	38	45	39	38	22	46	38	27	45	36	15	33	34	24	36	26	14	20	8	11	20	27	32
COL	55	55	42	46	38	42	45	48	46	33	21	37	19	19	19	26	20	25	18	17	18	4	15	18	15	30
TUN	64	42	48	49	24	45	37	46	42	48	19	30	29	17	20	21	30	19	22	8	16	21	11	11	8	29
LKA	70	68	22	39	35	48	46	47	54	32	19	9	18	30	8	24	10	21	17	6	9	6	6	13	16	27
CHL	62	56	38	16	46	9	38	28	32	39	32	30	22	14	17	27	26	30	14	24	15	5	23	12	18	27
MAR	72	58	29	34	17	39	25	41	38	18	20	24	35	26	19	25	27	24	19	8	14	5	4	16	10	26
EST	59	30	32	22	37	38	34	31	32	29	30	23	15	12	16	17	21	13	13	22	15	17	15	12	8	24
LVA	51	37	26	19	38	18	44	34	34	32	40	25	20	20	14	15	15	14	12	17	13	20	15	3	3	23
LTU	43	33	32	23	39	37	36	33	30	27	32	15	17	7	15	8	12	13	9	15	12	17	9	5	6	21
NZL	64	52	34	33	29	15	30	18	31	27	17	15	17	18	7	3	5	7	9	18	4	0	11	1	2	19
PAK	65	58	21	37	10	34	14	32	30	18	6	6	13	11	5	2	11	12	8	1	3	4	0	10	6	17
SVK	56	40	35	18	17	30	24	24	15	10	24	8	8	6	9	5	10	3	3	10	2	13	9	1	1	15
PHL	42	43	11	27	14	26	18	34	24	15	13	16	16	20	8	9	7	8	5	6	4	2	6	4	1	15
SVN	66	38	22	23	23	33	11	16	13	16	15	8	2	2	6	3	3	5	5	13	3	12	7	0	2	14
VNM	57	47	8	18	3	27	14	33	21	13	7	9	14	9	2	16	13	10	7	2	0	0	1	3	4	14
ROM	54	17	26	13	12	22	29	22	9	8	20	5	13	4	6	4	8	5	8	12	3	15	6	3	1	13
MEX	37	29	21	28	24	8	19	26	19	7	19	9	9	7	5	3	4	6	3	10	3	12	8	1	1	13
BGR	49	19	22	23	19	13	21	18	19	15	17	10	12	1	6	4	5	6	0	8	3	5	2	1	2	12
UKR	52	22	33	19	30	14	12	17	2	8	17	6	9	1	2	5	9	2	4	9	3	6	6	0	4	12
NOR	51	21	24	16	24	21	14	15	10	16	17	6	6	6	5	2	2	1	1	11	2	2	4	1	0	11
IRL	39	26	24	23	29	4	13	18	17	11	13	4	9	4	2	1	2	4	1	9	3	2	5	0	0	11
HUN	54	18	24	21	21	14	12	13	14	11	13	5	5	6	2	1	5	3	0	8	2	6	5	0	0	11
PRT	49	38	6	10	8	7	5	23	20	7	15	7	6	8	3	5	8	2	2	6	2	5	3	1	2	10
GRC	26	22	25	24	23	8	3	9	13	13	14	8	11	6	5	6	1	4	2	6	3	2	2	2	2	10
SGP	45	21	23	17	16	17	14	13	12	11	5	3	4	5	2	1	1	4	2	4	2	2	3	1	1	9
AUS	56	26	18	12	14	4	7	8	7	4	10	3	4	5	1	0	0	0	1	4	2	1	2	0	0	8
IDN	35	33	5	5	4	23	9	16	16	4	5	1	1	3	2	3	3	6	3	2	1	0	1	0	1	7
FIN	59	14	12	7	18	14	5	9	4	5	9	1	1	1	2	1	0	0	0	9	0	3	5	0	0	7
HKG	24	32	4	10	3	30	7	13	11	3	2	5	4	6	1	1	2	5	2	2	1	6	0	0	0	7
RUS	38	12	13	10	17	11	8	5	1	5	14	2	1	1	3	2	4	1	3	6	0	7	5	0	2	7
ZAF	31	12	13	16	18	3	9	10	5	10	8	4	5	2	1	0	2	2	0	5	1	2	4	0	1	7
MYS	21	19	22	5	10	11	8	15	12	7	12	1	4	3	3	1	0	3	1	2	1	1	1	0	0	7
BRA	41	26	13	4	5	4	4	8	5	3	8	1	8	5	2	1	5	3	1	6	1	0	3	1	1	6
CZE	45	18	12	10	14	7	4	6	3	1	9	0	2	1	0	0	2	0	1	6	1	6	3	0	0	6
THA	56	23	3	7	2	12	5	12	8	3	3	1	1	2	1	2	2	2	1	1	1	0	0	1	0	6
POL	29	18	13	6	16	10	2	6	3	3	7	0	3	2	1	0	1	1	0	6	0	2	1	0	0	5
JPN	40	4	6	17	9	15	2	1	4	1	1	1	1	1	1	0	1	0	1	2	1	2	1	0	0	4
KOR	38	5	9	15	6	13	3	4	1	2	4	0	1	0	0	0	1	0	0	1	0	2	0	0	0	4
SWE	37	4	10	6	11	3	3	4	0	4	6	0	0	1	1	0	0	0	1	4	0	2	2	0	0	4
CAN	55	4	6	3	7	5	2	3	2	1	1	0	2	1	1	0	0	0	0	2	0	0	2	0	0	4
DNK	22	10	9	10	7	6	4	7	4	1	6	0	2	0	0	0	0	0	0	2	0	0	1	0	0	4
TUR	42	6	7	7	5	14	1	1	0	0	1	0	3	0	0	0	1	0	0	0	0	0	0	0	0	4
AUT	39	7	7	4	8	2	3	4	5	3	1	0	0	2	0	0	0	0	0	0	0	1	0	0	0	3
IND	24	15	2	4	2	4	0	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
ITA	44	2	2	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
ESP	22	4	2	2	1	1	0	1	2	0	2	1	0	1	1	1	1	1	0	1	0	0	1	0	0	2
NLD	8	0	7	6	3	1	3	2	2	2	2	0	1	0	0	0	0	0	0	2	0	0	1	0	0	2
CHE	8	1	2	3	1	5	1	2	1	1	0	1	1	0	1	0	0	0	0	1	0	0	1	0	0	1
CHN	29	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
GBR	10	1	2	6	0	1	0	3	0	0	1	0	1	0	0	0	0	1	0	0	0	1	1	0	0	1
FRA	11	1	5	2	1	0	2	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
USA	7	1	2	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	1	0	0	1	0	0	1
DEU	3	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

C Appendix to Trade Probability: Reduced Form

It is also useful to analyze the marginal effect of a change in trade costs on the probability that a given country pair trade with each other with the reduced-form gravity equation. In order to compare the marginal effect of variable cost and fixed cost on trade probability, we standardize both trade costs, and then investigate the change in trade probability due to a one-standard-deviation decrease in variable and fixed cost, respectively. First we construct $VC = \rho \ln dist_{ij}$ and $FC = f_{ij}$ where $\rho = 0.117$, and VC and FC denote the variable and fixed costs, respectively. Then we standardize them by subtracting their means and divided by their standard deviations, resulting in variables of zero sample mean and unit sample variance. In order to get an average marginal effect of variable cost across exporters with heterogeneous price elasticities, we shut down the interaction terms $\ln r_i \times \ln dist_{ij}$ and $\ln P_j \times \ln r_i$ in equation (32). Then the specification of the symmetric AI gravity equation becomes

$$S_{ij}/N_i = -b_v VC_{ij} - b_f FC_{ij} + c \ln r_i \times \ln r_j + \delta \; Internal_{ij} + fe_i + fe_j + \varepsilon_{ij}, \tag{54}$$

and the observed trade share

$$\tilde{S}_{ij}/N_i = \begin{cases} S_{ij}/N_i, & \text{if } S_{ij} \geq 0, \\ 0, & \text{if } S_{ij} < 0, \end{cases}$$

where S_{ij} is the latent value of the systematic trade share. fe_i and fe_j are exporter- and importer-specific fixed effects, respectively. The dummy variable $Internal_{ij}$ is zero for import and one for the internal trade, capturing all the other unobserved trade cost across borders. We assume the error term $\varepsilon \sim$ Normal $(0, \sigma^2)$. Then the probability that a given country pair trade with each other is

$$Prob(S > 0) = Prob(\varepsilon > -\mathbf{X}\mathbf{b}) = \Phi(\mathbf{X}\mathbf{b}/\sigma), \tag{55}$$

where matrix $\mathbf{X}$ is the vector of all independent variables, $\mathbf{b}$ is the vector of all their coefficients in equation (54) and $\Phi(.)$ is the standard normal cumulative distribution function. Thus the marginal changes in trade probability due to trade costs are computed by

$$\frac{\partial Prob(S > 0)}{\partial VC} = \hat{b}_v \phi(\bar{\mathbf{X}}\hat{\mathbf{b}}/\hat{\sigma})/\hat{\sigma}, \tag{56}$$

and

$$\frac{\partial Prob(S > 0)}{\partial FC} = \hat{b}_f \phi(\bar{\mathbf{X}}\hat{\mathbf{b}}/\hat{\sigma})/\hat{\sigma}, \tag{57}$$

where $\phi(.)$ is the standard normal probability density function, and $\bar{\mathbf{X}}$ denotes the vector of mean values.

The results are reported in Table C.3. Row (1) shows the marginal changes in trade probability for the aggregate trade. One standard deviation decrease in VC improves the trade probability by 5 percentage points, while one standard deviation decrease in FC improves the trade probability by 3 percentage points. Since there are many fewer zeros in aggregate trade, we further report the results by sectors in row (2)-(26). All numbers are positive which implies lowering trade cost increases the trade probability. On average, one standard deviation decrease in VC improves the trade probability by 10 percentage points, while one standard deviation decrease in FC improves the trade probability by 2 percentage points. To visualize the results, Figure C.9 plots the results of marginal effects of VC and FC on trade probability respectively, as well as their 95% confidence intervals. VC raises the trade probability most in the petroleum, wood, and tobacco sectors, while least in the professional and scientific equipment, electric, and printing sectors. FC raises the trade probability most in the transport, textile, and machinery sectors, while least in the electric, paper, and professional and scientific equipment sectors. More importantly, marginal changes in trade probability due to VC are larger than to FC for all sectors, implying that variable cost is more important than fixed cost in trade policy adjustment to make trade to occur.

Table C.3: Marginal Effect on Trade Probability

		Variable cost		Fixed cost	
(1)	Aggregate	.046	(.0119)	.0282	(.0088)
(2)	Petroleum	.149	(.0116)	.0143	(.0089)
(3)	Wood	.1471	(.012)	.03	(.0101)
(4)	Tobacco	.145	(.0097)	.0224	(.0084)
(5)	Paper	.1327	(.0121)	.0049	(.0093)
(6)	NfMetals	.1238	(.012)	.0339	(.0095)
(7)	IronSteel	.1208	(.0121)	.0352	(.0095)
(8)	OthChem	.1201	(.0122)	.0053	(.009)
(9)	Footwear	.1179	(.0119)	.0072	(.0094)
(10)	MetalProd	.1044	(.0122)	.0073	(.0091)
(11)	Apparel	.1038	(.0122)	.0267	(.0094)
(12)	Rubber	.1016	(.0121)	.0141	(.0092)
(13)	IndChem	.1004	(.0122)	.032	(.0094)
(14)	NonMetal	.0979	(.012)	.0166	(.0092)
(15)	Glass	.0971	(.0121)	.0307	(.0094)
(16)	Beverages	.0884	(.012)	.0275	(.0094)
(17)	Textiles	.0879	(.0121)	.0407	(.0092)
(18)	Plastic	.0853	(.0121)	.0184	(.0092)
(19)	Transport	.0848	(.0122)	.0507	(.0092)
(20)	Leather	.0829	(.012)	.0146	(.0096)
(21)	Machines	.0826	(.0121)	.0346	(.009)
(22)	Furniture	.0811	(.012)	.0325	(.0099)
(23)	Food	.0605	(.0121)	.0294	(.009)
(24)	Printing	.0579	(.0122)	.0226	(.0091)
(25)	Electrics	.057	(.0121)	.0049	(.009)
(26)	ProfSci	.0563	(.0121)	.0062	(.0092)
	Mean	.0995		.0225	
	St. d.	.0276		.0127	

Notes: Table reports the marginal effect of one-standard-deviation decrease in trade costs on trade probability by estimating equation (54). Robust standard errors in parentheses.

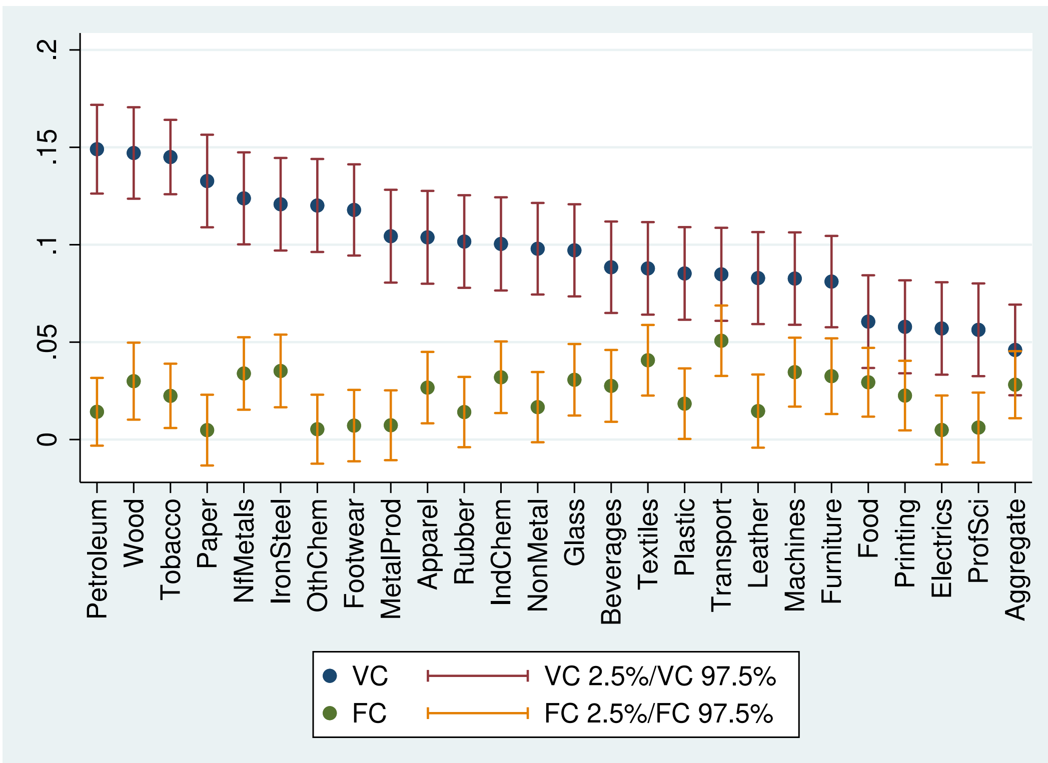

Figure C.9: Marginal Effect on Trade Probability