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ABSTRACT

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This paper provides new estimates of the effects of ethnic network on U.S. exports. In line with recent research, our dataset is a panel of exports from U.S. states to 29 foreign countries. Our analysis departs from the literature in two ways, both of which show that previous estimates of the ethnic-network elasticity of trade are sensitive to the restrictions imposed on the estimated models. Our first departure is to control for unobserved heterogeneity with properly specified fixed effects, which we can do because our dataset contains a time dimension absent from previous studies. Our second departure is to remove the restriction that the network effect is the same for all ethnicities. We find that ethnic-network effects are much larger than has been estimated previously, although they are important only for a subset of countries.

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I. Introduction

Information is essential for identifying advantageous exchange possibilities. In addition to information, confidence or trust that the parties involved in an exchange will perform according to their commitments is crucial before transactions are agreed upon. A lack of information and a lack of trust are frequently identified as informal barriers to trade. These informal barriers to trade likely deter international trade to a larger extent than domestic trade and, therefore, contribute to explaining why, even after adjusting for economic size and distance, intra-national trade flows tend to swamp international trade flows.[1]

Prior research, theoretical as well as empirical, has identified immigrant networks as an important intermediary that can mitigate these informal barriers in home-country markets by providing information about demand, languages, business practices, and laws, as well as instilling confidence to facilitate international trade. By reducing the cost of searching across national borders and by serving as a means of enforcing contracts, immigrants increase the likelihood of a match between a buyer and a seller that results in a completed transaction. Our focus is on how immigrant networks have affected U.S. exports at the level of individual states.

Our analysis departs from the existing literature in two ways. First, we allow for unobserved fixed effects when estimating our gravity model. As Cheng and Wall (2005) have demonstrated, gravity models that do not allow for fixed effects tend to provide biased estimates because such models fail to account for unobserved time-invariant factors that affect the level of trade and the independent variables used to explain the level of trade. Second, we allow for the

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[1] See McCallum (1995) for the seminal article exploring the impact of national borders. Obstfeld and Rogoff (2001) argue that even small differences in transactions costs can account for large border effects.

immigrant network effects to vary across ethnic groups. For various reasons, the export-immigrant network relationship is likely to differ across countries. For example, as stressed by Dunlevy (2005) the trade-stimulating effects of immigrants should tend to be greater when the host and source countries differ more in terms of institutions, languages, and cultures. Here is when the special skills associated with ethnic networks can provide essential information and contract-enforcement services.

To set the stage for our analysis, we review the existing literature in the next section. Next, we lay out the most general specification of ethnic networks in a common gravity model. This general version allows us to show very easily the different types of models that have been estimated, as well as our departures. To highlight the importance of our departures, we show results following the existing literature as well. We use the common gravity model to generate pooled cross section estimates and fixed-effect estimates when the network effect is assumed to be the same for all ethnicities. We then remove this restriction on the network effect and allow for country-specific network effects. Finally, we provide our most general estimates: country-specific gravity models with country-specific network effects.

II. Literature

The traditional focus of research exploring the connection between immigration and international trade has been on how immigration affected factor supplies in the source and recipient countries. The change in factor supplies affects production and, ultimately, trade

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flows.[2] Recently, most notably due to the research of James Rauch and various co-authors, attention has been drawn to the network effects associated with immigrants.[3] Immigrant networks are thought to lower the transactions costs of international trade by providing information about trade possibilities and by aiding the enforcement of contracts.[4] Beginning with work by Gould (1994), a number of empirical papers have attempted to identify and quantify this complementary link.

Table 1 contains a summary of the key empirical papers that have examined the impact of immigrant networks on international trade. In this section, we focus on the results for a subset of these studies, leaving the discussion of econometric methods to subsequent sections. Nearly all of the studies have focused on the trade flows of English-speaking countries. The major exception is a study by Rauch and Trindade (2002) that focuses on the impact of ethnic Chinese networks.

Because of our use of state exports, we restrict our discussion of existing studies to those that also use state exports. Many of the recent studies of U.S. trade have used exports at the state level to examine the immigrant-export connection.[5] Such a focus is potentially important because the immigrant-export connection depends on networks of individuals and families in which proximity is likely to play a role. The use of state-level data allows for the use of proxies that are closer to what is suggested by economic theory. The underlying theory suggests that an

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[2] In the Heckscher-Ohlin-Vanek framework, the movement of goods can be viewed as a movement of factor services. In a two-factor world, the exports of a capital-abundant country tend to contain larger amounts of capital services relative to labor services than its imports. Thus, the country is exporting capital services and importing labor services.

[3] See Rauch (2001) for a wide-ranging review of the literature.

[4] On the import side, immigrants may affect trade by purchasing goods produced in their home countries.

[5] The reason that these studies examine only exports is that state-level import data do not exist.

increase in the number of immigrants from a specific country into a specific state increases the source country information in the state. The increased information effectively reduces transaction costs, which stimulates exports from the state to the country. As Dunlevy (2005) has argued, if the effect of immigrants cannot be found at the state level, then doubt is cast on the results based on national data.[6]

Four recent studies — Co et al. (2004), Bardhan and Guhathakurta (2005), Herander and Saavedra (2005), and Dunlevy (2005) — have used state-level export data. The data in these studies covers the early to mid 1990s. Each examines the basic issue of the impact of immigrants on exports; however, they extend the basic literature in different ways. All are based on a gravity model, specifically a pooled cross-section model.

Co et al. (2004) examine state exports for 1993 using 48 states. They use 28 export destinations, 14 of which overlap with the destinations that we use. Export destinations are split into developed and developing countries. Separate network elasticities are estimated for the two sets of countries. These average elasticities are quite close, with an estimate of 0.29 for exports to developed countries and 0.27 for exports to developing countries.

Bardhan and Guhathakurta (2004) compare exports from the states on the east coast with those on the west coast using data for 1994-1996. The effects of two networks — one business network and one sociocultural — are explored. A statistically significant finding is that transnational business ties increase exports from both coasts. Meanwhile, a statistically significant relationship for immigrant networks is found only for west coast states. The ethnic-

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[6] Dunlevy (2005) also points out that this use of disaggregated data entails some assumptions that might not hold. For example, immigrants located in a specific state are assumed to affect exports from that state only. It is possible, however that these immigrants might affect exports from other states (Herander and Saavedra, 2005).

network elasticity of exports ranges from 0.24-0.26 for west coast states and 0.06-0.09 for east coast states.

Using state exports to 36 countries for 1993-1996, Herander and Saavedra (2005) examine the relationship between state exports and in-state and out-of-state immigrants. First, they examine the standard link between a state's immigrant population and its exports to the home country and find an ethnic-network elasticity of 0.18. Second, they argue that because a state's exporters have access to the ethnic networks of other states, the number of immigrants from the destination market in the rest of the states should also matter. As they expected, they found that there was a positive link between a state's exports to a country and the number of immigrants from that country in the rest of the United States.

The final study relying on state exports to study the link between exports and immigrants is by Dunlevy (2005). Using average exports to 87 countries for 1990-1992, Dunlevy estimates various specifications and finds a range for the ethnic-network elasticity of exports from 0.24-0.47. Dunlevy also examines four corollaries associated with the basic proposition of a link between exports and immigrants. He finds immigrant networks are especially useful for exports to countries with more corruption and to those with a less similar language. Institutional differences and differences across goods were not found to affect exports.

III. A Common Gravity Model

We estimate the effect of ethnic networks on state-level exports using a gravity model, as does most of the existing literature. In gravity models, the volume of trade between two partners

is a function of the sizes of the partners (gross domestic product (GDP) or its regional equivalent,

such as gross state product (GSP), and population) and the distance between them. Additionally,

gravity models control for cross-country differences in trade policy, usually by including dummy

variables to indicate membership in preferential trading areas. For our first three sets of

estimations, we use a gravity model that is common to all countries and states in the sense that

the coefficients on the traditional gravity variables are assumed to be the same across all

state/country pairs. The common gravity model with our most general specification of ethnic

networks is:

$$\ln x_{ij}^t = \alpha_{ij} + \tau_j^t + \beta \ln Y_i^t Y_j^t + \gamma \ln N_i^t N_j^t + \delta \ln Dist_{ij} + \eta Contig_{ij} + \lambda' \mathbf{Z}_j^t + \theta_j \ln F_{ij}^t + \varepsilon_{ij}^t. \quad (1)$$

In (1), i denotes a state, j denotes a country, and t denotes time. The dependent variable is x_{ij}^t,

exports from state i to country j in year t. The gravity variables in (1) control for size and

distance: Y_i^t is the GSP of state i, Y_j^t is the GDP of country j, N_i^t is the population of state i, N_j^t is

the population of country j, $Dist_{ij}$ is the distance between i and j, and $Contig_{ij}$ is a dummy

variable which takes the value of 1 if i and j are contiguous and zero otherwise.[7]

In addition to the gravity variables, equation (1) includes a vector $\mathbf{Z}_j^t$ that describes the

trade policy of country j, including its levels of import tariffs and whether or not it has a

preferential trading agreement with the United States. To account for exports to j that are

common across states but which differ over time, equation (1) also includes a time dummy τ_j^t

that is specific to country j. By allowing for time dummies to differ across countries, we are

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[7] As shown by Boisso and Ferrantino (1997), an equivalent specification replaces population with per capita gross domestic (state) product.

freed from having to quantify the trade stance of the countries, which is notoriously difficult. Instead, because $\mathbf{Z}_j^t$ and τ_j^t cannot be estimated separately, we combine them into a single country-specific time dummy, $\rho_j^t = \tau_j^t + \boldsymbol{\lambda}'\mathbf{Z}_j^t$.

Our first main departure from the literature is that we allow for properly specified fixed effects, which are denoted in (1) by α_{ij}.[8] As Cheng and Wall (2005) demonstrate, gravity models that do not allow for fixed effects tend to provide biased estimates because they fail to account for unobserved time-invariant factors that affect the level of trade as well as the independent variables that are used to explain the level of trade. Nonetheless, in common with the existing ethnic-network literature, we first estimate equation (1) without fixed effects.

The variable of most interest presently is F_{ij}^t, our proxy for the extent of ethnic networks, which is the number of residents of state i who were born in country j. Its coefficient, θ_j, is the ethnic-network elasticity of exports to country j. With the qualified exceptions of Rauch and Trindade (2002), Girma and Yu (2002), and Dunlevy (2005), every paper in the literature that has estimated the relationship has assumed that the ethnic-network elasticity is the same across countries.[9] In this sense, our second main departure from the literature is to allow for θ_j to differ across countries so as to identify differences in network effects across ethnic groups. It is reasonable to expect that the network effect associated with Irish immigrants to differ from that

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[8] There is somewhat of a semantic issue regarding what is and what isn't a model with fixed effects. According to the standard references (Hsiao, 1986 and Greene, 2003), fixed-effects models allow for intercepts to differ across cross-sectional units, which, in the case of trade, are trading pairs. Wagner, Head, and Ries (2002) include country dummies, while Dunlevy (2005) includes country and state dummies. Although a model with such dummies allows for some variation in intercepts, it does so in a highly restricted fashion and is not a fixed-effects model as described by Hsiao and Greene.

[9] Rauch and Trindade (2002) assume that the effect is zero for all but ethnic Chinese residents; Girma and Yu (2002) assume that for U.K. trade the effect is zero for all but members of the British Commonwealth; and Dunlevy (2004) uses interaction terms to allow the ethnic-network elasticity to vary across countries because of language, corruption, and institutional differences.

of Thai immigrants. Such a departure allows us to test whether the network effects, in fact, differ across ethnic groups. As we demonstrate later, the ethnic network effect found in existing studies is driven by a small number of countries.

Our dataset is limited by the availability of state-level data on the number of foreign-born residents, which is available from the decennial census and is sufficiently detailed only for 1990 and 2000. Nonetheless, this gives us two years of observations, which allows us to create a balanced panel and to control for fixed effects. To smooth out our data, our trade, income, and population variables are averages for 1988-1992 and 1998-2002. Distance is measured by the great-circle distance between largest cities. Our dataset has all nonzero exports from the 50 states plus the District of Columbia to 29 countries.[10] Because of the absence of a significant export relationship between a state and a country (i.e., exports equal zero in one or both three-year periods), we do not have 51 observations per year for all countries. In total, we have 2,912 observations of trade between 1,456 state/country trading pairs.

IV. Pooled Cross Section vs. Fixed-Effect Estimates

As mentioned above, because of data limitations, existing estimates the effect of ethnic networks on trade were limited to using the pooled cross section version of the gravity model. The most general of these allows for state and country effects (Dunlevy, 2005). This model can

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[10] Our export data are from the Massachusetts Institute for Social and Economic Research (MISER). In mid-2004 MISER was closed and succeeded by the World Institute for Strategic Economic Research (WISER). Our data are merchandise export shipments by state of origin of movement to various destinations throughout the world. Although this data is regarded as the best available for state exports, it has well-known weaknesses—the most important of which arise from the differences between the origin of movement and the origin of production. See Cronovich and Gazel (1999) and Coughlin and Mandelbaum (1991).

be obtained from equation (1) by assuming that each state/country fixed effect is the sum of a common intercept (α), a state dummy variable (λ_i), and a country dummy variable (ω_j). Although this allows for different intercepts across trading pairs, it does so by applying a complicated set of ad hoc restrictions on the trading-pair intercepts (Cheng and Wall, 2005).

For the time being, also assume that the network effect is the same for all ethnicities ($\theta_j = \theta$). Our pooled cross section regression equation is then

$$\ln x_{ij}^t = \alpha + \lambda_i + \omega_j + \rho_j{}^t + \beta \ln Y_i^t Y_j^t + \gamma \ln N_i^t N_j^t + \delta \ln Dist_{ij} + \eta Contig_{ij} + \theta \ln F_{ij}^t + \varepsilon_{ij}^t. \quad (2)$$

The results in Table 2 are from our estimation of equation (2) with and without the restriction that the effect of ethnic networks on trade is zero. The first set of results corresponds to a fairly typical gravity model that controls for changes in trade policy, the sizes of the trading partners, distance, and contiguity, but not for the effect of ethnic networks.[11] The results are quite standard: trade is positively related to economic size, negatively related to distance, and is higher for contiguous trading partners.

The second set of results in Table 2 is analogous to those in the existing literature that has estimated the effects of ethnic networks: It does not impose the restriction that the ethnic-network effect is zero, although it does restrict the effect to be the same across ethnicities. From the table it is clear that inclusion of the number of foreign born affects the results in two ways. First, the estimated ethnic-network elasticity is positive, statistically significant, and within the

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[11] All our equations are estimated by least squares. The existence of zero values for either the dependent variable or the independent variables raises problems for the estimation of a double log functional form. Recall, however, that our sample was chosen so that the level of exports was non-zero. To handle situations in which a state's immigrant population was zero, we simply added one to the level of the immigrant population.

typical range in the literature: A 10 percent increase in the number of residents born in a foreign country will increase state exports to that country by 2.4 percent. Second, inclusion of the foreign-born variable has a statistically significant effect on the rest of the model.[12] The estimates of β, δ, and η, for example, are very different when F_{ij} is included, suggesting that the the product of GDPs, distance, and contiguity are correlated with the number of foreign born. The general implication of this result is that gravity models that do not account for the effects of ethnic networks are providing biased estimates of the influence of other variables on trade volume.

Despite the apparent reasonableness of the preceding results from the pooled cross-section estimation, there are serious doubts about their validity. These doubts are based on the fact that this version of the gravity model does not account properly for unobserved (or not included) heterogeneity between state/country trading pairs that might account simultaneously for the level of exports from state i to country j as well as the number of residents in i that were born in j. Gravity models that do not account properly for these fixed effects have been shown to generate seriously biased estimates (Cheng and Wall, 2005), even when exporter and importer effects are included, as in our estimation of equation (2).

The presence of estimation bias is confirmed by Figure 1. In the figure, the residuals of the second estimation of equation (2) are plotted across the state/country pairs, with the pairs in descending order of their average residuals. These residuals clearly are not what would be obtained with an unbiased estimation of trade between state/country pairs. Instead of yielding an

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[12] A likelihood-ratio test rejects the null hypothesis that the restriction that $\theta = 0$ does not have a statistically significant effect on the estimation. The value of the test statistic, 88.3 (twice the difference in the absolute values of the log-likelihood functions) exceeds its corresponding critical value, which is $\chi^2(1) = 3.84$ at the 5-percent level.

average residual of zero for all trading pairs, about two-thirds of the trading pairs have residuals with the same sign for both observations.

We address the problem of bias by allowing each state/country pair to have its own unrestricted intercept. Note that doing so means that it is not possible to estimate the effects of distance and contiguity separately from the intercept. Specifically, the new intercept, which encompasses all variables that are fixed over time but which differ across state/country pairs, becomes $\sigma_{ij} = \alpha_{ij} + \delta \ln Dist_{ij} + \eta Contig_{ij}$. Because the effects of distance and contiguity are not of interest presently, however, this does not pose a problem. Our fixed-effects regression equation is

$$\ln x_{ij}^t = \sigma_{ij} + \rho_j^t + \beta \ln Y_i^t Y_j^t + \gamma \ln N_i^t N_j^t + \theta \ln F_{ij}^t + \varepsilon_{ij}^t. \tag{3}$$

We estimate (3) under the assumption that there are no ethnic-network effects, and then under the assumption that the ethnic-network effects are the same for all countries. The results of our estimations are summarized in Table 3. Note that the two earlier estimations of equation (2) summarized in Table 2 are restricted versions of the corresponding fixed-effects estimations in Table 3.

The first column of results in Table 3 indicates that the fixed effects model that does not control for ethnic networks performs as expected: The coefficients on both gravity variables have the expected sign and are statistically different from zero. Also, the fixed-effects version of the model is preferred statistically to the pooled cross section versions, i.e., a likelihood-ratio test easily rejects the hypothesis that the restrictions to obtain the results in the first column of results in Table 2 do not bias the results.

Our second estimation of equation (3) is the fixed-effects version of the standard

estimation in the ethnic-networks literature, which includes the ethnic-network variable and

assumes that the ethnic-network elasticity is the same across countries. Our estimated ethnic-

network elasticity is 0.132, which is statistically significant. Further, a likelihood-ratio test

comparing the results from the first and second columns rejects the hypothesis that restricting

this coefficient to zero does not bias the estimation. Note also that the inclusion of fixed effects

reduces the estimated ethnic-network elasticity and, because the fixed-effects version of the

model is preferred statistically to the corresponding pooled cross section version, the lower

estimate is the preferred one. This result suggests that previous studies provided biased

estimates of the ethnic-network elasticity of U.S. exports, tending to overstate the effect of such

networks on trade.

VI. Heterogeneous Ethnic-Network Effects

Having established that estimation of the ethnic-network elasticity of trade requires the

proper controls for trading-pair fixed effects, we can move on to our second point that the effects

of ethnic networks can differ dramatically across ethnicities. We estimate the following gravity

model, which differs from (3) only in that it relaxes the restriction that $\theta_j = \theta$:

$$\ln x_{ij}^t = \sigma_{ij} + \rho_j^t + \beta \ln Y_i^t Y_j^t + \gamma \ln N_i^t N_j^t + \theta_j \ln F_{ij}^t + \varepsilon_{ij}^t. \tag{4}$$

The results of this estimation are summarized in Table 4, in which the heterogeneity of

the ethnic-network elasticities is apparent. Further, a likelihood-ratio tests does not accept the

null hypothesis that the restriction that these elasticities are the same. These statistically most-

preferred estimates suggest that ethnic networks are important for only six countries, and that the

effects are much larger than has been estimated previously. The six countries whose estimated

ethnic-network elasticity is statistically different from zero are Brazil, Colombia, Ireland, South

Africa, Spain, and Turkey.

Note also that the ethnic-network elasticities for these countries are much larger than has

been found in any previous estimation. Only for South Africa is the elasticity less than one in

absolute value, and, even then, only slightly so. Oddly, though, these results also suggest that for

Colombia the ethnic-network elasticity is negative and very large: A 10-percent increase in the

number of residents born in Colombia should decrease exports to Colombia by nearly 20

percent.[13] Nevertheless, this version of the model and the results it provides are preferred

statistically to all other versions up to this point.

Our fairly large data set, which has nearly fifteen hundred observations for each of two

years, has allowed us to remove two sets of restrictions from the standard gravity model, both of

which are not supported statistically or by theory. It also allows us to remove even more

restrictions that might be biasing our above results. In particular, because we have at least 90

observations for each country, we can estimate separate country-specific gravity models, thereby

allowing the coefficients on the gravity variables to differ across countries. After all, in the

theoretical gravity model of Bergstrand (1989), it is perfectly reasonable to expect not only

different magnitudes on the coefficient on the population variable but also different signs. If

larger states (countries) are more self-sufficient, then population is related negatively to exports.

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[13] Additional discussion of the results for Columbia is provided later in the paper.

On the other hand, larger populations might promote a division of labor that increases trade

opportunities for a variety of goods. As a result, a model requiring identical coefficients for state

exports to various countries might not be appropriate for some countries. In other words, our

estimates might be biased by the restrictions that the signs on the gravity variables are the same

across countries.

We estimate separately for each country the following fixed-effects gravity model:

$$\ln x_{ij}^t = \sigma_{ij} + \rho_j^t + \beta_j \ln Y_i^t Y_j^t + \gamma_j \ln N_i^t N_j^t + \theta_j \ln F_{ij}^t + \varepsilon_{ij}^t. \tag{5}$$

The results of our estimations are summarized in Table 5. The first thing to notice is the

significant difference in the performance of the gravity model in explaining state exports, as

evidenced by the large differences in the magnitudes of the coefficients on the gravity variables,

the differences in R^2s, and in the results of *F*-tests. In fact, for Egypt, Spain, and Venezuela an

F-test fails to reject the null hypothesis that the model has no explanatory power.

For our purposes, the importance of allowing for country-specific gravity models is to see

how it affects the estimates of the countries' ethnic-network elasticities. For these results, there

are six countries whose estimated ethnic-network elasticities are statistically different from zero:

Brazil, Canada, Italy, South Africa, Spain, and Turkey. The elasticity for Italy is the largest: A

10 percent increase in the number of foreign residents should increase exports to Italy by just less

than 13 percent. For the other five countries, the elasticities are much larger than has been

reported in the literature, but are much smaller than what we found using the fixed effects model

that restricts the coefficients of the gravity variables to be the same across countries (Table 4).

Also note that the set of countries is different: While both models indicate that ethnic networks

are important for exports to Brazil, South Africa, Spain, and Turkey; Colombia and Ireland have been replaced by Canada and Italy. Finally, we no longer find that ethnic networks reduce exports to Colombia. The earlier, peculiar result arose because the gravity model for Colombia is extremely idiosyncratic: the coefficient on the income variable is very negative and is statistically significant. By assuming that the coefficients on the gravity variables were the same across countries, we were biasing the estimates of the ethnic-network elasticity for Colombia.[14]

VI. Conclusion

This paper we provide new estimates of the effects of ethnic network on U.S. exports. Our first contribution is to control for unobserved heterogeneity with properly specified fixed effects. Doing so results in a statistically significant ethnic-network elasticity that is about one-half of what is found using existing empirical methods.

Our second contribution is to remove the restriction that the network effect is the same for all ethnicities. Our statistical results, which are consistent with economic theory, reveal that ethnic-network elasticities vary across countries. Prior research examining the relationship between immigrants and international trade has tended to estimate a single ethnic-network elasticity for trade flowing from one country to a group of countries. The possibility that the ethnic-network elasticity differed across countries was recognized previously; however, prior to our attempt, no one attempted to estimate separate ones for exports to different countries. Our

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[14] Because Mexico provides by far the largest number of foreign-born residents and California is home to by far the largest number of foreign-born residents, outliers are a potential problem. To check for this, we estimated our model with Mexico and California excluded from the data set and found no substantive difference in the results.

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bottom line is that ethnic-network elasticities are actually much more important than has been reported previously, but that they are most important for a subset of countries.

We must stress, however, that we are not arguing that immigrant networks are unimportant for exports to countries in which we do not find statistical significance. Our analysis relies on the standard proxy for immigrant networks that is based on the number of immigrants in a state. This proxy is undoubtedly less than ideal and may be seriously flawed as a measure of networks for some countries. Networks are not necessarily larger for each new immigrant, but rather depend on the skills of the immigrants, which might not be accurately gauged by the quantity of immigrants.[15]

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[15] In their study of Canadian exports, Head and Ries (1998) found that immigrants classified as independents (mostly professionals) affected trade relatively more than entrepreneurs and refugees.

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Table 1. Summary of Empirical Papers

	Data	Econometrics	Ethnic-network elasticity of exports	Ethnic-network elasticity of imports
Gould (1994)	U.S. aggregate trade, 1970-1986, 47 countries	Not a gravity model	0.02	0.01
Head and Ries (1998)	Canadian aggregate trade, 1980-1992, 136 countries	Simple PCS	0.10	0.31
Dunlevy and Hutchinson (1999)	US aggregate and disaggregated trade 1870-1910, 17 countries	Simple PCS	0.08	0.29
Rauch and Trindade (2002)	63 countries, disaggregated trade, 160 countries	Simple PCS	0.47 (differentiated)	0.47 (differentiated)
Girma and Yu (2002)	U.K. aggregated trade, 1981-1993, 48 countries	Simple PCS, effect of foreign born from Commonwealth	0.16 (non-Commonwealth)	0.10 (non-Commonwealth)
Wagner, Head, and Ries (2002)	Canadian provinces, 1992-1995, 160 countries	PCS with country dummies	0.013	0.092
Co, Euzent, and Martin (2004)	U.S. state exports, 1993, 28 countries	Simple PCS	0.27 – 0.30 0.27 low income 0.29 high income	
Bardhan and Guhathakurta (2004)	U.S. state exports, 1994-1996, 51 countries	Simple PCS, east coast vs. west coast	0.24 - 0.26 W 0.06 - 0.09 E	
Herander and Saavedra (2005)	U.S. state exports, 1993-1996, 36 countries	PCS with state and country dummies, includes out-of-state network effect	0.18	
Dunlevy (2004)	U.S. state exports, 1990-1992 average, 87 countries	PCS with state and country dummies	0.24 – 0.47	
Bryant, Genç, and Law (2004)	New Zealand aggregate trade, some disaggregation, 1981-2001, 170+ countries	Random effects	0.05 (all goods) 0.10 (exc. ag)	0.19 (all goods) 0.23 (exc. oil)
Mundra (2005)	U.S. aggregate trade, intermediate and finished goods, 1973-1980, 47 countries	Semiparametric fixed effect instrumental variable in a panel	Not estimated, network effect for finished goods, but not necessarily for intermediate goods	Not estimated, network effect always positive

Notes: PCS = pooled cross section. Unless otherwise noted, all papers use a gravity model. Some of the elasticity calculations are from Wagner, Head, and Ries (2002).

Table 2. Pooled Cross-Section with Common Network Effect

	No Network Effect ($\alpha_{ij} = \alpha$ and $\theta_j = 0$)			Common Network Effect ($\alpha_{ij} = \alpha$ and $\theta_j = \theta$)		
	Coeff.	S.E.	t-stat.	Coeff.	S.E.	t-stat.
Intercept (α)	-4.622	5.897	-0.78	-4.778	5.809	-0.82
State and country dummies	yes			yes		
Time/policy dummies (ρ_j)	yes			yes		
ln $Y_i Y_j$ (β)	0.839*	0.358	2.35	0.769*	0.352	2.18
ln $N_i N_j$ (γ)	0.819	0.524	1.56	0.615	0.517	1.19
ln $Dist_{ij}$ (δ)	-0.581*	0.098	-5.91	-0.389*	0.099	-3.93
$Contig_{ij}$ (η)	0.646*	0.175	3.68	0.332*	0.176	1.89
ln F_{ij} (θ)	-			0.237*	0.025	9.28
Log-likelihood	-3594.39			-3550.23		
F-statistic	F(61, 2800) = 101.74			F(62, 2799) = 104.53		
$\overline{R}^2$	0.784			0.779		

A '*' indicates statistical significance at the 10 percent level.

Table 3. Fixed-Effects Model with Common Network Effect

	No Network Effect ($\theta_j = 0$)			Common Network Effect ($\theta_j = \theta$)		
	Coeff.	S.E.	t-stat.	Coeff.	S.E.	t-stat.
Pair-specific intercept (α_{ij})	yes			yes		
Time/policy dummies (ρ_j)	yes			yes		
ln $Y_i Y_j$ (β)	0.839*	0.256	3.27	0.800*	0.257	3.12
ln $N_i N_j$ (γ)	0.819*	0.376	2.18	0.706*	0.378	1.86
ln F_{ij} (θ)	-			0.132*	0.055	2.39
Log-likelihood	-1642.80			-1636.98		
F-statistic	F(31,1425) = 24.64			F(32,1424) = 24.13		
$\overline{R}^2$ (within)	0.349			0.352		

A '*' indicates statistical significance at the 10 percent level.

Table 4. Country-Specific Networks

	Country Network Effects (θ_j unrestricted)		
	Coeff.	S.E.	t-stat.
Pair-specific intercept (α_{ij})	yes		
Time/policy dummies (ρ_j)	yes		
ln $Y_i Y_j$ (β)	0.880*	0.262	3.36
ln $N_i N_j$ (γ)	0.599	0.387	1.55
ln F_{ij} (θ_j)			
Argentina	0.294	0.632	0.46
Australia	-0.538	0.938	-0.57
Brazil	1.291*	0.622	2.08
Canada	0.574	1.171	0.49
Chile	-0.252	0.506	-0.50
China	-0.040	0.981	-0.04
Colombia	-1.989*	0.724	-2.75
Egypt	-0.842	0.731	-1.15
France	0.353	1.107	0.32
Germany	0.354	1.604	0.22
Hong Kong	0.182	0.462	0.39
India	1.009	0.837	1.21
Indonesia	0.625	0.500	1.25
Ireland	1.915*	1.001	1.91
Israel	0.471	0.503	0.94
Italy	1.535	1.079	1.42
Japan	0.051	1.321	0.04
Malaysia	-0.168	0.413	-0.41
Mexico	0.174	0.378	0.46
Netherlands	0.064	1.025	0.06
Philippines	-0.214	1.123	-0.19
South Africa	0.930*	0.384	2.42
South Korea	-0.113	1.117	-0.10
Spain	1.584*	0.826	1.92
Sweden	0.010	0.572	0.02
Thailand	1.347	0.858	1.57
Turkey	2.276*	0.778	2.92
United Kingdom	1.042	1.554	0.67
Venezuela	-0.600	0.528	-1.14
Log-likelihood	-1595.07		
F-statistic	F(60,1396) = 13.66		
$\overline{R}^2$ (within)	0.370		

A '*' indicates statistical significance at the 10 percent level.

Table 5. Country-Specific Gravity Models

	Time dummy		$\ln Y_i Y_j$		$\ln N_i N_j$		$\ln F_{ij}$		$F\left(4,\dfrac{n}{2}-1\right)$	$\overline{R}^2$ (within)	n
	ρ	s.e.	β	s.e.	γ	s.e.	θ	s.e.			
Argentina	0.128	0.710	0.187	1.250	3.369*	1.855	-0.043	0.255	25.88	0.697	98
Australia	0.371	0.248	1.346	0.973	-1.699	1.458	-0.071	0.314	3.13	0.211	102
Brazil	0.072	0.414	0.941	1.315	0.222	1.980	0.571*	0.270	15.24	0.570	100
Canada	0.253*	0.110	0.054	0.456	0.665	0.707	0.453*	0.203	42.68	0.784	102
Chile	-0.408	0.889	0.613	1.382	1.584	1.929	-0.134	0.218	5.95	0.341	100
China	-2.120	1.501	3.788*	1.728	-3.299	2.444	-0.278	0.565	18.71	0.614	102
Colombia	1.560*	0.883	-3.697*	1.853	7.885*	2.300	-0.607	0.400	10.94	0.493	98
Egypt	-1.658	1.760	4.357	2.988	-5.693	3.624	-0.360	0.395	1.76	0.147	90
France	0.113	0.141	0.506	0.745	-0.720	1.131	0.366	0.285	2.88	0.197	102
Germany	0.110	0.126	0.179	0.662	-0.092	1.119	0.532	0.413	3.16	0.212	102
Hong Kong	-0.956	0.609	1.675	1.083	0.555	1.601	0.022	0.171	9.53	0.448	102
India	-0.813	0.495	5.841*	1.817	-5.197*	2.136	-0.175	0.547	5.65	0.334	98
Indonesia	-0.235	0.462	4.892*	1.644	-3.782	2.461	0.356	0.270	3.46	0.231	100
Ireland	-1.937	1.189	3.184*	1.853	0.856	2.820	0.546	0.625	11.42	0.498	100
Israel	-0.499	0.815	-0.717	1.574	4.180*	2.491	0.046	0.277	7.07	0.376	102
Italy	0.532*	0.189	2.357*	0.977	-4.406*	1.572	1.267*	0.386	4.18	0.262	102
Japan	-0.340*	0.183	1.642*	0.702	-1.775*	0.988	0.187	0.329	2.19	0.157	102
Malaysia	-0.242	1.043	-2.798	2.357	9.700*	3.692	-0.453	0.333	11.42	0.493	102
Mexico	0.563	0.466	-0.591	0.915	2.373*	1.292	0.140	0.114	42.89	0.785	102
Netherlands	-0.280	0.245	-0.198	0.958	3.128*	1.494	-0.162	0.345	3.61	0.235	102
Philippines	-0.250	0.690	0.777	1.666	2.795	3.085	-0.681	0.943	7.99	0.405	102
South Africa	-0.129	0.520	0.001	1.243	0.043	1.848	0.430*	0.157	3.28	0.218	102
South Korea	0.301	0.516	-0.393	1.306	1.070	1.903	0.117	0.486	2.72	0.188	102
Spain	-0.135	0.215	-0.075	1.148	-0.160	1.662	0.828*	0.313	1.99	0.145	102
Sweden	-0.093	0.324	0.533	1.361	0.952	2.130	-0.016	0.266	0.55	0.045	102
Thailand	0.124	0.439	-0.679	1.558	2.068	2.359	0.586	0.448	4.81	0.295	100
Turkey	-1.364*	0.604	-1.223	2.140	5.890*	3.044	0.788*	0.476	4.52	0.301	92
United Kingdom	-0.400	0.301	1.955*	0.878	-1.809	1.398	0.777	0.586	6.72	0.364	102
Venezuela	-1.304	0.825	2.093	1.388	-0.555	1.884	-0.335	0.221	1.67	0.127	100

A '*' indicates statistical significance at the 10 percent level.

Figure 1. Residuals from Pooled Cross Section