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PATTERNS OF INTRA- AND INTER-STATE TRADE

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ABSTRACT

Recent studies suggest that *intra*national trade is "excessive" compared to *inter*national trade. An intuitive explanation for this home bias is provided by national trade barriers. A dataset of trade between US states, however, reveals that home bias extends to subnational units. The data suggest three additional stylized facts. First, shipment distances are shorter for intermediate than for final goods. Second, states located close to each other tend to have similar production patterns. Third, trade flows are higher among states with similar production patterns. The stylized facts are consistent with a complementary explanation of home bias resulting from a spatial clustering of production driven by natural and created comparative advantage.

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1 Introduction

Recent work on trade suggests that *intra*-national trade is "excessive" compared to *inter*-national trade, relative to some baseline model of normal trade including distance as one of its determinants. Thus Canadian provinces seem to trade about twenty times more with other Canadian provinces than with equi-distant and equi-sized US states [McCallum (1995), Helliwell (1995,1996)] while the internal trade of OECD economies appears to dominate international trade, again controlling for distance and size [Wei (1996)]. One obvious explanation for this "home bias" in trade among geographic units separated by political borders are national trade barriers: tariffs, quotas, exchange rate variability, multi-currency transaction costs, different standards and customs *etcetera* arguably all favor intra-national over inter-national trade on the margin.

Whether national trade barriers provide a full explanation however remains an open question, for two reasons. First, the *size* of the bias -factor twenty in the case of Canadian provinces relative to US states- seems very large relative to the known extent and impact of trade barriers, attribution of home bias to national barriers would thus require either very significant hidden trade barriers or a very significant response of trade flows to even small barriers. Neither conjecture appears strongly supported by empirical studies. Second, and related, if national trade barriers are indeed the culprit for home bias, it should, in principle, be possible to eliminate the bias by augmenting the baseline trade model with measures of these barriers. To date, effort in this direction has met with mixed success. Wei (1996) examines in a cross section whether the extent of home bias can be attributed to exchange rate volatility, but finds no significant effect. Recent work on informal barriers appears more promising, in particular, an intriguing body of work suggests a strong and maybe causal link between migration and trade, consistent with important informal barriers that can be overcome by local contacts.[1]

While it is thus *a priori* intuitive to suspect national trade barriers as a culprit in home bias, it is less evident whether they are the sole or even dominant cause. In this paper we conduct a simple test of the importance of trade-barriers in explaining home bias: using a dataset of trade between and within the contiguous states of the US, we examine whether home-bias is also present at the sub-national level. The strong constitutional protections

[1]See Egan and Mody (1992), Gould (1994), Head and Ries (1996) and Helliwell (1997).

for inter-state commerce, the all but irrevocably fixed exchange rate between states and the fairly high degree of cultural and institutional homogeneity suggests that neither formal nor informal trade barriers play a mayor role in driving trade between US states, hence the presence of home bias on the sub-national level would be indicative of additional reasons for "excessive" local trade. We find that home-bias does indeed extend downward to the level of sub-national units, suggesting that trade barriers must be augmented by other factors to obtain a full explanation of home bias.[2]

The trade barrier explanation attributes home bias to a jump in transaction costs: the additional costs, whether explicit or implicit, for shipments crossing borders requires additional compensatory gains from international compared to national trade. The jump in transaction costs thus induces a kink in the trade-distance relation, shifting the marginal international trade into the domain of domestic trade.

The explanation for home bias on the subnational level might similarly reflect spatial non-linearities[3] in transaction costs. Recent work in industrial organization, trade and growth points to a number of potential causes of such non-linearities, ranging from spatial spillovers on the demand or supply side,[4] spatial clustering of (immobile) factors[5], or an uneven spatial distribution of demand, again coupled with high transportation costs [Melvin (1985b)]. Notably, most of these explanations suggest that the spatial externality occurs within sectors, resulting in a high degree of spatial concentration of production stages, and hence of trade in intermediate goods, even if the spatial distribution of final good consumption is fairly even.

Figure 1, plotting the average shipment distance for trade among the US states by commodity group, provides some indirect evidence. While all groups contain both intermediate and final products, the table reveals some bias towards shorter shipments for categories

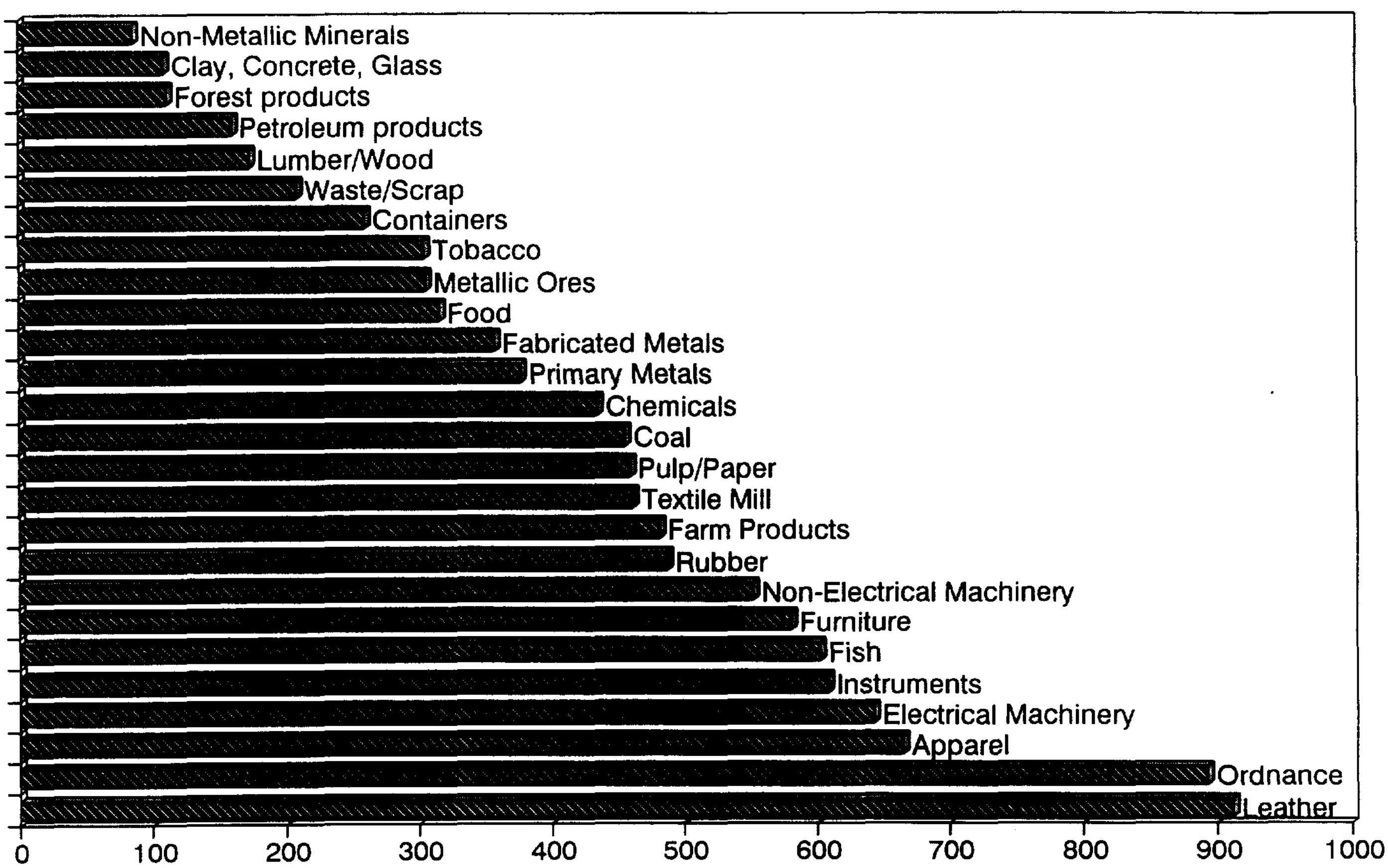
[2]The presence of substantial "home-bias" on the sub-national level for such a highly integrated area also carries implications for the likely evolution of trade patterns within areas now pursuing trade integration, notably the Maastricht signatories, a point not further examined here.

[3]Of course, transport costs themselves will lead to a bunching of production stages, these linear effects are however taken account of in the baseline model of trade determination, "home bias", in a sense made more precise below, refers to the positive *residual* intra-state trade after controlling for linear distance effects.

[4]See Marshall (1920), Henderson (1974), Carlton (1983), Fujita (1988), David and Rosenbloom (1990), Rauch (1993), Krugman and Venables (1995) and Head, Ries and Swenson (1995) *inter alia*, for applications.

[5]Melvin (1985a), Courant and Deardorff (1992).

Average Shipment Distance (Miles)



with a high input component. Thus the average shipment distance for wood and lumber is 174 miles, compared to 581 miles for furniture; textile mill products are shipped 462 miles, compared to 665 miles for apparel.[6]

Importantly, neither trade barriers nor spatial externalities suffice as explanations. A model of home bias built around trade barriers cannot explain why home-bias is observed for sub-national units not subject to significant trade barriers. A story of home bias based on spatial externalities cannot explain why this clustering should occur within the arbitrary boundaries of a particular political entity. In conjunction, trade barriers with spatial externalities can explain both findings: trade barriers will lead clusters to locate within political boundaries. To the degree that trade patterns display hysteresis[7] (as one would expect in the presence of spatial externalities due to the co-ordination problem of joint relocations) the presence of sizable barriers at some past time suffices, de-emphasizing the importance of small current barriers.

The remainder of the paper is structured as follows. We begin with a brief discussion of the baseline model used to define "home-bias". We then describe the data before presenting the empirical results.

2 Methodology

Home **bias** is only defined relative to a baseline model of "normal" trade. Despite substantial progress, a consensus model of trade determination remains elusive, reflecting the difficulty of convincingly separating the alternative model classes, in particular endowment models with extensive specialization and models of differentiated products.[8] We follow precedent by foregoing the use of more specialized models in favor of a modified version of the gravity approach [Linnemann (1959), Tinbergen (1962), Armington (1969a,b)] to specify baseline trade. The gravity model provides a useful benchmark [Rauch (1996)] for two reasons. First, it is consistent with both endowment models and differentiated product

[6] To place the results in perspective, the average shipment distance for all products equals 255 miles, one fifth of the average 1219 mile distance between a state and the other contiguous states, revealing that a significant portion of manufactures and commodities - classic "tradables" - are on average exported mostly to the neighboring states rather than across the United States, another manifestation of "home bias".

[7] See Baldwin and Krugman (1989), Eichengreen and Irwin (1996).

[8] At least using trade data. See Davis and Weinstein (1996) and Deardorff (1995).

models.[9] Second, it boast an impressive track record.[10] The basic gravity model relates bilateral trade flows between two markets to the product of their market size and their distance:

$$ln(T_{ij}) = \alpha_0 + \beta_1 ln(Y_i Y_j) + \beta_2 ln(D_{ij}) + X\gamma \qquad (1)$$

where T_{ij} denotes the total trade between states i and j, Y measures real GDP and D_{ij} is the distance between the two states. X denotes a set of auxiliary variables further discussed below. We follow the standard practice of entering the activity variables multiplicatively, implying that trade between two equal sized states exceeds trade between a large and a small state with the same aggregate output.[11]

In line with previous studies, we augment the simple gravity specification by a set of additional controls: productivity (the log of the sum of value added per worker in manufacturing in the two trading partners), a control for population density (the log of the product of bilateral distance with the population density in both trading partners) and dummies for a shared land border, shared access to the great lakes and joint location on either the Atlantic or the Pacific. Following Deardorff (1995) and Wei (1996), we also include a measure of *remoteness* permitting the effect of bilateral distance to vary with the proximity of third trading partners: controlling for remoteness permits two states located close to each other but far from all their trading partners to trade more with each other than two equally distant states closer to their trading partners. Remoteness for a given pair of states i and j is measured as the ratio of their bilateral distance to the average of their output weighted mean distance to all states:[12]

[9] See Anderson (1979), Asilis and Rivera-Batiz (1994), Davis and Weinstein (1996), Deardorff (1995), Harrigan (1994).

[10] A sample of recent applications and surveys includes Bergstrand (1985,1989), Deardorff (1984), Frankel, Stein and Wei (1993), Helpman (1987), Hummels and Levinsohn (1995), Rauch (1996), Sanso et al. (1993), and Wei (1996) among others.

[11] As part of the robustness tests, we have re-computed results with an alternative additive formulation, with very little effect on the other coefficient estimates and slightly lower explanatory power.

[12] The appropriate measurement of remoteness remains a topic of active debate. Wei (1996) uses an alternative approach of adding, for each trading partner, the output weighted mean distance to all other trading partners. See also Helliwell (1997).

$$R^{i,j} = \frac{D_{ij}}{0.5 * \sum_{a=1}^{48} \frac{Y_a}{\sum_{b=1}^{48} Y_b}(D_{ia} + D_{ja})} \tag{2}$$

In the regression, we expect a negative sign: for a given distance from other states, greater bilateral distance reduces trade, for a given bilateral distance, greater distance from other states increases trade. The remoteness measure is plotted in Figure 1, revealing a fairly close bunching at the lower end of the distribution, while Nevada, Idaho, California, and in particular Oregon and Washington are the most remote.

The third group of controls comprises measures of the dissimilarity of the production (P_{ij}) and the trade (T_{ij}) structure between two states i and j. Lacking data on the sectoral composition of bilateral trade, the proxies are computed as the sum of the absolute share differences based on total state trade and total state production:

$$T_{ij} = \sum_{a=1}^{n} abs(\frac{EX_{ia}}{\sum_{b=1}^{48} EX_{ib}} - \frac{EX_{ja}}{\sum_{b=1}^{48} EX_{jb}}) \tag{3}$$

where EX_{ia} denotes exports of good a from state i and n denotes the number of export categories. Similarly:

$$P_{ij} = \sum_{a=1}^{m} abs(\frac{Y_{ia}}{\sum_{b=1}^{m} Y_{ib}} - \frac{Y_{ja}}{\sum_{b=1}^{m} Y_{jb}}) \tag{4}$$

where Y_{ia} denotes production in sector a in country i and m denotes the number of production sectors. Informally, similarity of production patterns proxies for similarity of endowments, one might thus expect states with similar production patterns to trade more with each other to the extent that intra-industry trade is important, but to trade less with each other to the extent that endowment differences matter for trade, with similar effects for the trade-composition measure. The relatively aggregated nature of our data - twenty-five sectors for the trade, fifty-two sectors for the output composition - implies that this interpretation is subject to the same caveat as other attempts to disentangle differentiated product models from endowment based models with a high degree of specialization.

3 Data

Trade is measured by the dollar value of shipments, taken from the 1993 Commodity Flow Survey. The sample covers a total of 1030 bilateral observations for the 48 continental states[13] based on an establishment based shipper survey conducted by the Bureau of Transportation, covering approximately a quarter of the establishments on the 1992 Standard Statistical Establishment List. The sample covers rail, for-hire truck, private truck, air, inland water, deep-sea water, pipeline, US Postal Service and courier transportation. Surveyed establishments were requested to list origin and destination addresses, along with value and weight, which were used to construct within state and across-state shipment flows.

The survey covers mining (except mining services), food and kindred products, tobacco products, textile mill products, apparel, lumber and wood products, furniture, paper and allied products, printing and publishing (except services), chemicals, petroleum refining, rubber and miscellaneous plastics products, leather and leather products, stone, clay, glass and concrete products, primary metals industries, fabricated metals products, industrial and commercial machinery, computer equipment, electronic and other electrical equipment, transportation equipment, instruments, wholesale trade, catalog and mail order houses, motion pictures and video tape distribution, covered under SIC codes 10 (except 108), 12 (except 124), 14 (except 148), 20-26, 27 (except 279), 28-39, 50,41,596 and 782. The sample excludes agriculture, government and retail trade, along with services.

The dataset suffers from two known problems. First, the data on crude petroleum and natural gas shipments are poor, reflecting insufficient survey returns, and are hence excluded. Second, exports abroad are counted as shipments to the final domestic location, imports as shipments from the first location in the US to the final destination. While the fairly low import and export ratio for the United States suggests that this is not a major problem, it obviously may affect individual trade intensive industries. As a control we have included, in addition to the ocean-dummies, the total trade going through all major customs-locations in either of the two trading partners as an additional control in the regressions. The coefficient is generally small and insignificant and is not reported in the regression results below.

[13] A number of bilateral flows were unreported for reasons of data reliability or sensitivity.

The data for gross state product (GSP) and population were taken from the United States Statistical Abstract. Controlling for the potential endogeneity of output to trade, we use 1991 GSP data [Helliwell (1997)]. To be on the safe side, results were re-estimated using population instead of state GSP as scaling variable and instrumenting for GSP. The results are very sturdy to these modifications.

The distance between states is measured as the minimum driving distance in miles between the largest city in each state, taken from the RandMcNally Road Atlas and the RandMcNally Tripmaker CD. The previous literature, largely studying non-contiguous groups of countries, has more commonly used the great circle distance. Since the majority of shipments between US states are transported either by road or by a road-rail combination, minimum driving distance appears preferable, though by and large the difference between minimum driving and great circle distance is of second order.[14]

The distance for intra-state trade, D_{ii} is measured in two alternative ways. First, as the distance between the largest and the second largest city *within* the state. Second, as one-half of the average distance to all adjacent states. The production scale variable for intra-state trade is computed by splitting state GDP into two equal halves.

4 Results

The results on the determinants of inter- and intra-state trade are reported in Tables 1 and 3. Table 1 reports the core results, on which most of the discussion is focused. Table 3 contains a set of robustness tests examining the sturdiness of the results to a range of modifications. The top rows of the tables provides additional information on the regression. *"Add. Controls"* denotes whether additional controls for joint location on the Pacific, the Atlantic and the great lakes and the control for international trade from major custom districts are included. These controls are added in all but the first two regressions, are generally insignificant and, to avoid cluttering the table, are not reported. *"In-State"* reports whether the forty-eight *intra*-state observations are included alongside the 982 *inter*-state observations.

[14] In the sample year, the modal distribution, in terms of ton-miles of freight, was as follows: rail: 33.0%, highways: 25.3%, water: 23.5%, pipeline: 17.6% and air: 0.3%. Source: National Transportation Statistics Yearbook 1996.

Table 1: **Gravity Equation: Baseline Results**

Dep. Variable	Trade	Trade	Trade	Trade	Trade	Trade
Technique:	OLS	OLS	OLS	OLS	OLS	OLS
Observations:	1030	1030	1030	1030	1030	982
Add. Controls	No	No	Yes	Yes	Yes	Yes
Intra-State:	Yes	Yes	Yes	Yes	Yes	No
	1	2	3	4	5	6
$Constant$	-8.06	-11.24	-13.18	-10.23	-24.93	-27.62
	(21.04)	(24.19)	(24.04)	(18.09)	(19.13)	(20.17)
$ln(Y^1Y^2)$	0.961	0.986	1.036	0.942	0.914	0.958
	(66.23)	(70.81)	(60.28)	(52.36)	(50.16)	(50.50)
$ln(\sum VA(Manufac.)$					0.906	0.995
					(12.05)	(12.86)
$Y-Dissimilar$				-1.350	-1.052	-0.984
				(8.04)	(6.60)	(6.36)
$T-Dissimilar$				-10.202	-13.297	-10.803
				(4.29)	(6.00)	(4.99)
$ln(Distance)$	-0.956	-0.417	-0.294	-0.307	-0.215	-0.183
	(33.69)	(7.44)	(5.13)	(5.76)	(4.07)	(3.16)
$Remote$		-1368.3	-1208.6	-1086.8	-1142.7	-1192.32
		(10.94)	(10.15)	(9.72)	(10.42)	(10.31)
$Adjacent$			0.858	0.765	0.807	0.836
			(11.78)	(11.21)	(12.58)	(13.21)
$Dist.*Dens.^1*Dens.^2$					11.274	12.152
					(10.12)	(9.52)
$Intra-Trade$	1.338	1.554	1.110	0.333	0.461	
	(11.68)	(14.10)	(10.51)	(2.88)	(4.22)	
R2	0.867	0.881	0.903	0.916	0.929	0.925

Column (1) in Table 1 reports the results for the basic gravity model, a regression of the log of trade on the log of the product of state GDPs, the log of distance between the two states and a dummy for intra-state trade, the latter aiming to capture "home-bias" defined as a significant difference between intra- and inter-state trade controlling for other determinants. The R^2 of 0.867 confirms the excellent overall explanatory power of the gravity approach noted in previous studies. The good fit of the model of course partly reflects the presence of unscaled variables on both sides of the regression, yet, as 'documented below, even if the trade variable is scaled by state GDP the standard gravity regression explains more than eighty percent of the variance of bilateral trade. State economic size enters highly significantly, with a near unitary elasticity, while increasing distance reduces bilateral trade, with an elasticity close to minus one. The dummy on intra-state trade (alias "home bias") shows up highly significant and positive, based on the basic gravity equation, the home bias found for cross-country studies thus also seems to be present for individual US states. Comparing the anti-log of the home-bias coefficient with the coefficients found by McCallum (1995) and Helliwell (1996,1997) for border dummies suggests however that intra-national home-bias is lower (by factor five) than inter-national home bias, a finding consistent with Helliwell (1997).

In column (2) we add the remoteness measure -defined as the ratio of the bilateral distance to the average of the GDP weighted distances of the two trading partners to all other states - to the basic regression. The highly significant and negative coefficient confirms that the importance of distance for explaining bilateral trade depends on the location of the trading partners relative to all other trading partners: for a given *bilateral distance* between two states, their trade increases in the distance to their other trading partners. Home bias survives this modification, the coefficient on the intra-state trade dummy remains significant and positive. In column (3) we add the adjacency dummy to the explanatory variables, finding a positive and significant effect of adjacency on trade controlling for distance. The effect is familiar from previous studies looking at trade across national borders, yet it is puzzling in the present context: while in the case of cross-border trade, additional costs associated with shipping via a third country may lead to higher trade between adjacent countries, the strong constitutional protections of inter-state commerce render this explanation implausible for the case of US states. A possible explanation is that states are too large as observational units. If trade is highly localized, a finding consistent with the very small average shipment distances documented in Table 1, adjacency effects could arise from spatial clusters straddling state borders.

How do these results compare with earlier studies? Table 2 reports the baseline regressions of McCallum (1995) and Wei (1996) together with (as nearly as possible) identical regressions based on the US dataset.[15] The first two columns compare McCallum's (1995) findings for a set of Canadian provinces with the results for the US states. To match the Canadian dataset, the intra-state observations are dropped, the regression hence can only be used to compare overall fit, not the presence of home bias. The regressions are highly similar, explaining almost ninety percent of the variance of exports for the Canadian provinces and almost eighty percent for the US states. The last two columns contrast the results obtained by Wei (1996) for a sample of OECD economies, including intra-country trade, with the equivalent regression performed for the US states.[16] The income elasticities are seen to be considerably lower for the OECD countries compared to either the Canadian provinces or the US states, possibly reflecting a lower degree of integration among the OECD economies. For both datasets, "home-bias" in trade is observed: OECD economies and US states trade more within their border than would be predicted based on income, distance and remoteness.

The comparison with McCallum (1995) and Wei (1996) reveals a substantial degree of similarity across the three datasets and suggests that "home bias" is a quite sturdy feature both for inter- and for intra-national trade. We now examine to what extent the "home-bias" finding in the basic gravity model survives in a richer specification. Column (4) of Table 1 adds the two proxies for the dis-similarity of the trade (T-Dissimilarity) and the production (Y-Dissimilarity) structure. A larger value for both measures suggests a more *dissimilar* trade and production structure. Both indices enter significantly with a negative coefficient, indicating that states with a more similar production composition and states with a more similar trade composition engage, ceteris paribus, in more bilateral

[15] As both authors focus on exports, these regressions use shipments from state A to state B as the dependent variable, while the regressions reported in tables 1 and 3 use the sum of outward and inward shipments. One difference between the datasets is the availability of multiple years of observation for both the Canadian and the OECD dataset, in contrast to the single year of observations available for the US states.

[16] Both regressions employ Wei's (1996) definition of remoteness as the output weighted average distance to other trading partners.

Table 2: **Comparison With Previous Results**

	Canadian Provinces McCallum (1995)	US States	OECD Countries Wei (1996)	US States
$ln(Y^i)$	1.30	0.97	0.70	0.93
	(21.66)	(38.56)	(23.33)	(40.38)
$ln(Y^j)$	0.96	0.99	0.75	1.03
	(16.00)	(43.95)	(25.00)	(47.05)
$Distance^{ij}$	-1.52	-1.03	-0.98	-0.78
	(15.2)	(31.42)	(16.33)	(19.12)
$ln(Remote^i)$			0.28	-0.46
			(2.33)	(4.22)
$ln(Remote^j)$			0.60	0.68
			(5.00)	(6.04)
Home Bias			0.94	1.53
			(3.76)	(11.98)
Observ.	90	982	361*4	1030
Adj. R^2	0.890	0.819	0.89	0.867

trade than states with dissimilar trade and production structures. The finding is more in accord with intra-industry than with inter-industry trade models, though, again, the level of disaggregation is insufficiently high to satisfactorily rule out inter-industry trade with a high degree of specialization.

The degree of output similarity is in turn correlated positively with the product of market size, adjacency and the product of value added per worker in manufacturing, while decreasing in distance. The similarity of trade composition is influenced in the same manner, though productivity in manufacturing is insignificant:

$$
\begin{array}{llllll}
Y - Dis - Simi. = & 1.51 & -0.0027ln(Y^1Y^2) & +0.038ln(Dist.) & -0.138Adj. & -0.043ln(VA^1VA^2) \\
 & (5.78) & (8.49^{***}) & (5.55^{***}) & (8.48^{***}) & (2.59^{**}) \\
 & & & & & R^2 = 0.304 \\
 & & & & & \\
T - Dis - Simi. = & 0.081 & -0.003ln(Y^1Y^2) & +0.0026ln(Dist.) & -0.0086Adj. & -0.000ln(VA^1VA^2) \\
 & (4.44) & (13.63^{***}) & (5.55^{***}) & (7.58^{***}) & (0.00) \\
 & & & & & R^2 = 0.332
\end{array}
\quad (5)
$$

Larger, closer, adjacent and highly productive states thus tend to exhibit a greater similarity of both their trade and their output structure, a feature in turn linked to larger trade *volume*. Yet these variables remain significant even if the measures of output and trade dissimilarity are included, suggesting a direct effect beyond their influence on the similarity measures.

Column (5) in table 1 adds the controls for productivity (the log of the sum of value added per worker in manufacturing in the two states) and the population density control (the product of the bilateral distance and the population densities in the two trading partners). The resulting equation is our baseline specification and is repeated here for convenience:

$$
\begin{aligned}
ln(Trade) = \quad & -24.93 && +0.914 * ln(Y^1Y^2) && +0.906 * ln(\sum VA) \\
& (19.13^{***}) && (50.16^{***}) && (12.05^{***}) \\
& -1.052 * Y - Sim. && -13.297 * T - Sim. && -0.215 * ln(Dist.) \\
& (6.60^{***}) && (6.00^{***}) && (4.07^{***}) \\
& -1142.7 * Remote && +0.807 * Adj. && +11.274 * Dist * Dens * Dens \\
& (10.42^{***}) && (12.58^{***}) && (10.12^{***}) \\
& +0.461 * Home - Bias && && \\
& (4.22^{***}) && R^2 = 0.929 &&
\end{aligned}
\tag{6}
$$

The results confirm the key findings of the earlier literature: changes in state GSP, both in the importing and the exporting state, affect bilateral trade with a near-unitary elasticity, a greater distance reduces trade. The inclusion of the other controls reveals a number of additional determinants of bilateral trade. First, more productive states tend to trade more with each other. Second, states with similar production structures tend to trade more with each other. Third, states with similar trade patterns tend to trade more with each other. Fourth, for a given bilateral distance, states that are jointly remote from third trading partners tend to trade more with each other [Deardorff (1995), Wei (1996)]. Fifth, greater population density reduces the negative effect of distance.

The coefficient on intra-state trade ("home bias") drops in size and significance relative to the basic gravity specifications. The drop is of course at least partially attributable to the fact that the similarity indices which, by construction, are equal to zero for the forty-eight intra-state observations, pick up part of the variation previously explained by the intra-state dummy. To examine whether the results depend on the intra-state observations, column (6) re-estimates the baseline regression excluding the intra-state observations. The overall fit as well as the sign pattern, size and significance of coefficients are quite similar, suggesting that results are not driven by the intra-state observations.

Table 3 examines the robustness of these results. Column 1 replaces output by population as the scale variable. With the exception of the now insignificant coefficient on output similarity, the results seem unaffected. Column 2 uses the average of one-half the distance to all neighboring states as the measure of intra-state distance (rather than, as in

Table 3: **Gravity Equation: Robustness Tests**

Dep. Variable	Trade	Trade	Trade	Trade	$\frac{T1+T2}{Y1+Y2}$	$\frac{T1*T2}{Y1Y2}$
Technique:	IV	OLS	OLS	OLS	OLS	OLS
Observations:	1030	1030	1030	1030	1030	1030
Add. Controls	Yes	Yes	Yes	Yes	Yes	Yes
In State	Yes	Yes	Yes	No	Yes	Yes
	1	2	3	4	5	6
Constant	-38.42	-25.94	-23.01	-25.75	-29.42	-49.39
	(25.94)	(19.43)	(17.51)	(19.84)	(20.36)	(15.38)
$ln(Y^1Y^2)$	0.922	0.913	0.889	0.949		
	(44.06)	(49.51)	(48.84)	(51.14)		
$ln(\sum VA(Manufac.)$	1.273	0.939	0.827	0.895	1.589	2.918
	(15.82)	(12.41)	(11.09)	(12.32)	(15.99)	(16.33)
$Y-Similar$	0.209	-1.014	-1.107	-0.983	-1.507	-2.395
	(1.18)	(6.37)	(7.08)	(6.37)	(6.89)	(6.08)
$T-Similar$	-15.386	-13.743	-12.930	-10.639	-34.397	-59.116
	(6.36)	(6.18)	(5.96)	(4.92)	(12.05)	(11.52)
$ln(Distance)$	-0.283	-0.126	-0.256	-0.189	-0.269	-0.642
	(4.91)	(2.30)	(4.23)	(3.31)	(3.72)	(4.93)
Remote	-1078.7	-1304.3	-783.04	-1210.4	-982.05	-1877.2
	(9.01)	(11.70)	(6.49)	(10.60)	(6.54)	(6.95)
Adjacent	0.824	0.838	0.880	0.840	0.808	1.609
	(11.76)	(12.88)	(13.68)	(13.34)	(9.17)	(10.15)
$Dist.*Dens.^1*Dens.^2$	14.977	10.933	10.194	9.294	9.939	14.489
	(12.112)	(9.80)	(9.243)	(8.44)	(6.58)	(5.34)
$Intra-Trade$	0.878	0.524	0.576	5.768	0.636	1.464
	(7.23)	(4.78)	(5.30)	(6.54)	(4.31)	(5.51)
Distance less than $100m$			-0.094			
			(3.06)			
Distance more than $1200m$			-0.036			
			(5.31)			
$Distance*Intra-State$				0.327		
				(3.08)		
$GDP*Intra-State$				-0.324		
				(8.58)		
R2	0.915	0.928	0.932	0.934	0.809	0.834

the other regressions, the distance between the largest and the second-largest city within the state). No significant changes in the coefficient patterns emerge. The third column examines the possibility of non-linearities in the distance measure. Based on a grid search with a 50 mile interval, two thresholds were found: the (absolute) elasticity of bilateral trade with respect to bilateral distance appears to be higher at short distances of less than 100 miles and at long distances of more than 1200 miles. Controlling for this non-linearity, the other coefficients are however again largely unaffected, in particular, the intra-state dummy measuring home bias is not affected by allowing distances below 100 miles to enter with a greater elasticity.

Column 4 allows the market size and distance elasticities to differ for intra- and inter-state trade. Both market size and distance exert a lesser effect for intra-state trade, however, the other coefficients are again largely unaffected and the intra-state dummy remains significant and positive. The last two columns report results for scaled versions of the gravity model, using the ratio of the sum of trade to the sum of GDP (column 5) and the ratio of the product of trade to the product of GDP (column 6). While the explained variance declines, the scaled version of the gravity model remains able to explain more than eighty percent of the variance in the dependent variable. The sign pattern of the explanatory variables remains unchanged, all variables continue to enter significantly. The intra-state dummy proxying for home bias effects remains significant and positive for both scaled versions.

5 Conclusion

Recent studies on the determinants of intra- versus inter-national trade have established a tendency for "excessive" intra-national trade, measured relative to the gravity specification as benchmark model of trade. Understanding the causes of this *home bias* in trade is of evident interest. One possible explanation is the presence of national trade barriers shifting trade on the margin towards intra-national partners. The observed degree of home bias however seems to be too large relative to what is known about the extent and significance of trade barriers, casting doubt on whether such barriers can provide a complete explanation.

Shifting the focus to inter- versus intra-state trade within a country permits an indirect test: if national factors are the core of the home-bias puzzle, we should not observe home bias for sub-national units. Using a dataset on shipments between US states we however do in fact find strong evidence of home bias on this more disaggregated level: intra-state trade is "excessive" (defined vis a vis a baseline gravity model) relative to inter-state trade just as inter-state trade is excessive relative to inter-national trade. In consequence, factors other than national trade barriers must provide at least part of the explanation of home bias.

One possibility deserving further exploration is clustering, reflecting natural and created spatial comparative advantage. To the extent that such clusters primarily occur within sectors, aggregate home-bias in trade would be observed even if final goods are not subject to "excessive" local trade, a possibility suggested by the longer average shipment distance for final compared to intermediate products.

Of course, spatial clustering only suggests home-bias in the sense of a non-linear effect of distance, not home bias in the sense of higher trade within political boundaries: spillovers should not end at the borderposts. However, in the presence of some trade barriers, clusters may well be located within rather than across political boundaries. Given the strong constitutional protections for inter-state commerce, it is less clear why clusters would occur within US states. Two explanations spring to mind. First, industrial policies, both past and present, might play a role. Second, it might be that states are too large (in the spatial sense) as observation units. If trade divides into two parts, *intra-sector* sector trade taking place within clusters of below-state size and final good trade taking place over distances above typical state sizes, we would observe both "home bias" (reflecting a non-linearity in the distance elasticity, consistent with our finding of a higher (absolute) elasticity of trade with respect to distance below 100 miles) and a positive adjacency effect (reflecting clusters straddling state boundaries).

References

[1] Andersen, James (1979); "A Theoretical Foundation For The Gravity Equation"; *American Economic Review*; 69: 106-16.

[2] Armington, Paul (1969a); "A Theory of Demand For Products Distinguished By Place Of Production"; *IMF Staff Papers*; March: 16:1: 159-78.

[3] Armington, Paul (1969b); "The Geographic Pattern Of Trade And The Effect Of Price Changes"; *IMF Staff Papers*; July: 16:2: 179-199.

[4] Asilis, Carlos and Luis Rivera-Batiz (1994); "Geography, trade Patterns, and Economic Policy"; IMF Working Paper No. 94/16.

[5] Baldwin, Richard and Paul Krugman (1989); "Persistent Trade effects Of Exchange rate Shocks"; *Quarterly Journal of Economics*; 104: 635-654.

[6] Bergstrand, Jeffrey (1985); "The Gravity Model in International Trade"; *Review of Economics and Statistics*; 67: 474-81.

[7] Bergstrand, Jeffrey (1989); "Generalized Gravity Equation, Monopolistic Competition, And The Factor-Proportions Theory In International Trade"; *Review of Economics and Statistics*; 71: 143-53.

[8] Carlton, Denis (1983); "The Location And Employment Choices Of New Firms"; *Review of Economics and Statistics*; 440-49.

[9] Courant, Paul and Alan Deardorff (1992); "International Trade With Lumpy Countries"; *Journal of Political Economy*; 100:1:198-210.

[10] David, Paul and Joshua Rosenbloom (1990); "Marshallian factor externalities and the dynamics of industrial location"; *Journal of Urban Economics*; 28: 349-70.

[11] Davis, Donald and David Weinstein (1996); "Does Economic Geography Matter For International Specialization?"; NBER Working Paper No. 5706.

[12] Deardorff, Alan (1984); "Testing Trade Theories and Predicting Trade Flows"; in R. Jones and P. Kenen (eds.) **Handbook of International Economics**; Vol. 1: Amsterdam, Elsevier, pp. 467-517.

[13] Deardorff, Alan (1995); "Determinants Of Bilateral Trade: Does Gravity Work In A Neoclassical World?"; NBER Working Paper No. 5377.

[14] Egan, Mary Lou and Ashoka Mody (1992); "Buyer-Seller Links in Export Development"; *World Development*; 20: March: 321-34.

[15] Eichengreen, Barry and Douglas Irwin (1996); "The Role Of History In Bilateral Trade Flows"; NBER Working Paper No. 1996.

[16] Frankel, Jeffrey, Ernesto Stein and Shang-Jin Wei (1993); "Trading Blocs"; UC Berkeley Working Paper.

[17] Fujita, Masahisa (1988); "Monopolistic Competition and Urban Systems"; *European Economic Review*; 37: 308-15.

[18] Gould, David (1994); "Immigration and Trade Creation"; *Review of Economics and Statistics*; 76:2: May: 302-16.

[19] Harrigan, James (1994); "Scale Economies and the Volume of Trade"; *Review of Economics and Statistics*; 76: May: 321-28.

[20] Head, Keith, John Ries and Deborah Swenson (1995); "Agglomeration Benefits and Location Choice"; *Journal of International Economics*; 38: 223-47.

[21] Head, Keith and John Ries (1996); "Immigration and Trade Creation"; Mimeo.

[22] Helliwell, John (1997); "National Borders, Trade and Migration"; Mimeo.

[23] Helliwell, John (1996); "Do National Borders Matter For Quebec's Trade"; *Canadian Journal of Economics*; 29, April.

[24] Helliwell, John and John McCallum (1995); "National Borders Still Matter For Trade"; *Policy Options*; 16: July/August, 44-48.

[25] Helpman , Elhanan (1984) ; "The Factor Content Of Foreign Trade"; *Economic Journal*; 94: March: 84-94.

[26] Helpman, Elhanan (1987); "Imperfect Competition and International Trade"; *Journal of the Japanese and International Economies*; 1: 62-81.

[27] Henderson, J. (1974); "The Sizes and Types of Cities"; *American Economic Review*; 64: 640-56.

[28] Hummels, David and James Levinsohn (1995); "Monopolistic Competition and International Trade"; *Quarterly Journal of Economics*; 110:3: 799-836.

[29] Krugman, Paul (19991); "Increasing Returns and Economic Geography"; *Journal of Political Economy*; 99: 3: 483-99.

[30] Krugman, Paul and Anthony Venables (1995); "The Seamless World"; NBER Working Paper No. 5220.

[31] Linneman, Hans (1966); **An Econometric Study of International Trade Flows**; Amsterdam, North Holland.

[32] Marshall, Alfred (1920); **Principles of Economics**; 8th edition, , London: MacMillan.

[33] McCallum, John (1995); "National Borders Matter: Canada-US Regional Trade Patterns"; *American Economic Review*; 85, June, 615-23.

[34] Melvin, James (1985a); "The Regional Economic Consequences of Tariffs And Domestic Transport Costs"; *Canadian Journal of Economics*; 18: May: 237-57.

[35] Melvin, James (1985b); "Domestic Taste Differences, Transportation Costs, and International Trade"; *Journal of International Economics*; 18: February: 65-82.

[36] Rauch, James (1991); "Comparative Advantage, Geographic Advantage, And The Volume of Trade"; NBER Working Paper No. 3512.

[37] Rauch, James (1993); "Does History Matter Only When It Matters Little?"; *Quarterly Journal of Economics*; 843-67.

[38] Rauch, James (1996); "Networks Versus Markets In International Trade"; NBER Working Paper No. 5617.

[39] Sanso, Marcos, Rogelio Cuairan and Fernando Sanz (1993); "Bilateral Trade Flows, The Gravity Equation, And Functional Form"; *Review of Economics and Statistics*; 75: May: 266-75.

[40] Tinbergen, Jan (1962); **Shaping The World Economy**; New York, Twentieth Century Fund.

[41] Wei, Shang-Jin (1996); "Intra-National Versus International Trade"; NBER Working Paper No. 5531.