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Comparing the fit of the gravity model for different cross-border flows

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Abstract

This paper investigates how well the gravity model explains various cross-border flows that may lead to knowledge spillovers. It turns out that the model works well for trade and telephone traffic, but less satisfactorily for merger and acquisition flows.

Keywords: Trade; Telephone traffic; Merger and Acquisition; Gravity model

JEL classification: F21; F23; G34

1. Introduction

This paper investigates how well the gravity model fits three cross-border flows that may lead to knowledge spillovers and productivity growth: trade, telephone traffic, and merger and acquisition (M&A) flows.[1] Because these flows are likely to be endogenous, instruments are needed to identify their effects on income and productivity. Some researchers find that the gravity model produces good instruments for trade and telephone traffic and use the model to identify the effects of trade and telephone traffic on cross-country income and productivity levels (Frankel and Romer, 1999; Wong, 2004). There is some evidence that distance and a common language also affect bilateral M&A activity (Di Giovanni, 2005). Thus, it is natural to ask whether the gravity model can also be used to identify M&A's effects on income and productivity.

The evidence suggests that the gravity model works well for trade and telephone traffic, but less satisfactorily for M&A flows. In contrast to trade and telephone traffic, the evidence suggests that the missing values in M&A flows are not only pervasive but also non-random.

2. Methodology and results

To compare the performance of the gravity model, I regress the bilateral flows on bilateral geographic, linguistic, and colonial characteristics:

$$\begin{aligned}\ln \mathrm{FLOW}_{ij} = {} & a_0 + a_1 \ln D_{ij} + a_2 \ln N_i + a_3 \ln A_i + a_4 \ln N_j + a_5 \ln A_j \\ & + a_6 (L_i + L_j) + a_7 B_{ij} + a_8 B_{ij} \ln D_{ij} + a_9 B_{ij} \ln N_i \\ & + a_{10} B_{ij} \ln A_i + a_{11} B_{ij} \ln N_j + a_{12} B_{ij} \ln A_j \\ & + a_{13} B_{ij} (L_i + L_j) + a_{14} \mathrm{LANGUAGE}_{ij} + a_{15} \mathrm{BRITAIN}_{ij} \\ & + a_{16} \mathrm{FRANCE}_{ij} + a_{17} \mathrm{SPAIN}_{ij} + \mu_{ij}, \end{aligned} \quad (1)$$

where i refers to the home country and j denotes the partner country. FLOW_{ij} represents either Trade_{ij}, Tel_{ij}, or $\mathrm{M\&A}_{ij}$. Specifically, Trade_{ij} is the bilateral trade share between countries i and j, measured as exports plus imports as a ratio

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[1] There are various hypothesis about how these flows can lead to technology diffusion. See Keller (2004) for a literature review. For example, in the case of foreign direct investment, multinational enterprises (MNEs) may transfer firm-specific technology to its foreign subsidiaries. MNEs may also generate positive externalities through labor training and turnover (Fosfuri, Motta, and Ronde (2001)), or through backward linkages (Rodriguez-Clare (1996)). Specifically, technology spillovers may arise if MNEs train local workers, who are later hired by local firms. MNEs may also encourage the production of a greater variety of specialized inputs in the host countries, which in turn pormotes the development of higher value-added industries.

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of GDP in country i. Tel_{ij} is the outgoing telephone call traffic from country i to country j, divided by the number of workers in country i. $M\&A_{ij}$ is the bilateral M&A flows from country j to country i as a ratio of GDP in country i.

The explanatory variables are defined as follows: D is distance, N is population, A is area, L is a dummy for landlocked countries, B indicates whether two countries share a common border; $LANGUAGE_{ij}$ measures the probability that a randomly drawn person from country i speaks the same language as a randomly drawn person from country j; BRITAIN, FRANCE, and SPAIN are dummies that indicate colonial ties between the ex-colonizers and their ex-colonies.

I estimate regression (1) with OLS. Because of missing values in some of the bilateral flows, the OLS estimates only allow us to draw conclusions for the sub-sample of countries with observed values. Following Di Giovanni (2005), to account for censoring bias due to the missing values, I also estimate a Heckman selection model using the two-step estimator and the maximum likelihood estimator (MLE).[2] If the flow data are missing randomly, then the OLS estimates and the Heckman estimates should be similar. Furthermore, the error terms in the outcome Eq. (1) and the selection equation should be uncorrelated. It turns out that both of these predictions hold for trade and telephone traffic, but not for M&A.

2.1. Data and results

All data come from the year 1999. Telephone traffic data come from TeleGeography's Traffic Database. Trade data come from IMF's *Direction of Trade Statistics* (DOTS). M&A data come from Di Giovanni (2005), whose data in turn come from a database produced by Thomson Financial Securities Data. This database has also been used by Rossi and Volpin (2004) to investigate the determinants of M&A activity.[3] The data on geographic, linguistic, and colonial variables come from Frankel and Romer (1999) and Wong (2004).

Columns (1), (4), and (7) of Table 1 report the OLS estimates of Eq. (1). The coefficients generally have the expected signs. For example, bilateral flows are lower if two countries are further apart or if their country sizes allow for more internal interactions relative to external ones, i.e., if the home country is larger or if the partner country is smaller, holding constant population density.[4] On the other hand, bilateral flows are higher if two countries share a common border or a common language. The landlocked dummy and colonial ties have no statistically significant effect on M&A shares. In contrast, trade and telephone traffic flows are significantly lower if at least one of the countries are landlocked and significantly higher if there are colonial ties between the countries.

It is worth noting that while the geographic, linguistic, and colonial variables explain 39% of the variations in telephone traffic and trade, they explain only about 24% of the variations in M&A flows. Furthermore, missing values are pervasive for bilateral M&A flows. There are only 597 country-pair observations for bilateral M&A flows, compared to 15,312 observations for bilateral trade flows and 3198 observations for bilateral telephone traffic flows.[5]

Thus, while gravity factors matter, the fit of the model is poorer for cross-border M&A flows. In contrast to trade and telephone traffic, cross-border M&A are long-term financial commitments in foreign countries. Thus, it seems likely that other factors, such as investor protection and corporate governance – determined partly by legal origin and religion – may be especially important for M&A.[6] General lack of protection, for example due to corruption, can significantly reduce inward FDI flows (Wei, 2000). More specifically, there is evidence that companies from countries with better investor protection tend to acquire companies in countries with lower protection (Rossi and Volpin, 2004)[7] and the speed of convergence in shareholder protection is correlated with cross-border M&A activity (Pagano and Volpin, 2006).[8] Furthermore, La Porta et al. (1998) show that shareholder protection is determined by legal origin while Stulz and Williamson (2003) show that creditor rights and its enforcement are influenced by religion. Nevertheless, Khanna et al. (2006) highlight the importance of distinguishing between de jure convergence of corporate governance (the adoption of similar laws on books) and de facto convergence (convergence of actual practices). They show that higher bilateral trade and FDI flows, shorter distance, a common language and a common legal origin are correlated with de jure convergence but not with de facto convergence. It is worth noting that while this literature is generally motivated by the hypothesis that higher cross-border flows cause convergence in corporate governance, the evidence never rules out reverse causation: convergence in corporate governance may also facilitate greater cross-border flows.

[2] For the two-step estimator, I first estimate the selection equation – a probit for whether a flow is observed or not – conditional on the same right-hand side variable as in Eq. (1), and construct the inverse Mills ratio. I then run the outcome Eq. (1), including the inverse Mills' ratio as an additional regressor. I adjust the standard errors for the fact that a regressor, the inverse Mills ratio, is constructed.

[3] They find that the volume of M&A activity is positively correlated with bilateral trade, the difference in investor protection and income per capita.

[4] In other words, I consider a simultaneous increase in population and area.

[5] These problems are not unique to this FDI data set. As a robustness check, in results not shown here, I re-estimate the bilateral regression using an alternative FDI data set by the United Nations Conference on Trade and Development (UNCTAD, 2002, 2003, 2004). I use all available data with positive FDI inflows into countries in East Asia, South Asia, Latin America, Central and Eastern Europe in 1999. There are only 582 observations. Most of the qualitative results on M&A still hold. However, the model still explains only 25% of the variations in FDI, much less than for trade and telephone traffic.

[6] Some of these variables may also affect trade through the efficiency of legal enforcement. Anderson and Marcouiller (2002) show that trade expands dramatically when it is supported by strong institutions — specifically, by a legal system capable of enforcing commercial contracts and by transparent and impartial formulation and implementation of government economic policy.

[7] They argue that value is created because the former provides governance to the latter.

[8] They argue that M&A, by allowing firms to opt out of national company law, increases the support for greater domestic shareholder protection.

Table 1
Determinants of trade, telephone call traffic, and M&A

Estimation method	Dependent variable								
	$\ln Trade_{ij}$			$\ln Tel_{ij}$			$\ln M\&A_{ij}$		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	OLS	2-Step	MLE	OLS	2-Step	MLE	OLS	2-Step	MLE
Constant	−12.08	−11.26	−11.99	−1.61	−1.63	−1.61	−18.57	−29.08	−22.48
	[0.36]***	[0.90]***	[0.36]***	[0.75]**	[1.94]	[0.76]**	[1.73]***	[20.49]	[2.59]***
$\ln D_{ij}$	−1.22	−1.17	−1.21	−1.04	−1.05	−1.04	−0.24	−0.9	−0.48
	[0.03]***	[0.06]***	[0.03]***	[0.06]***	[0.43]**	[0.08]***	[0.11]**	[1.29]	[0.16]***
$\ln N_i$	0.03	−0.02	0.02	−0.03	−0.03	−0.03	−0.64	−0.24	−0.49
	[0.02]	[0.05]	[0.02]	[0.04]	[0.06]	[0.04]	[0.09]***	[0.80]	[0.11]***
$\ln A_i$	−0.1	−0.09	−0.1	−0.3	−0.3	−0.3	0.14	0.08	0.12
	[0.01]***	[0.02]***	[0.01]***	[0.03]***	[0.06]***	[0.03]***	[0.06]**	[0.14]	[0.07]*
$\ln N_j$	1.16	1.13	1.16	0.81	0.81	0.81	0.54	0.99	0.71
	[0.02]***	[0.04]***	[0.02]***	[0.04]***	[0.18]***	[0.04]***	[0.09]***	[0.89]	[0.13]***
$\ln A_j$	−0.31	−0.3	−0.31	−0.17	−0.17	−0.17	−0.1	−0.23	−0.15
	[0.01]***	[0.02]***	[0.01]***	[0.03]***	[0.04]***	[0.03]***	[0.06]*	[0.26]	[0.06]**
L_i+L_j	−1.06	−0.99	−1.05	−1.59	−1.59	−1.59	−0.01	−0.31	−0.12
	[0.05]***	[0.08]***	[0.05]***	[0.10]***	[0.12]***	[0.10]***	[0.29]	[0.65]	[0.27]
	6.6	6.04	6.54	12.06	12.07	12.06	8.28	11.14	9.36
	[2.04]***	[2.12]***	[1.32]***	[2.58]***	[2.76]***	[2.61]***	[5.40]	[7.97]	[4.24]**
$B_{ij}\ln D_{ij}$	0.64	0.59	0.63	0.42	0.42	0.42	−0.88	−0.5	−0.74
	[0.26]**	[0.26]**	[0.21]***	[0.30]	[0.44]	[0.30]	[0.58]	[0.96]	[0.49]
$B_{ij}\ln N_i$	−0.33	−0.3	−0.32	−0.35	−0.35	−0.35	−0.33	−0.43	−0.37
	[0.13]**	[0.14]**	[0.10]***	[0.18]*	[0.19]*	[0.17]**	[0.34]	[0.42]	[0.26]
$B_{ij}\ln A_i$	−0.04	−0.04	−0.04	−0.08	−0.08	−0.08	0.45	0.3	0.4
	[0.14]	[0.14]	[0.11]	[0.17]	[0.17]	[0.17]	[0.28]	[0.43]	[0.16]**
$B_{ij}\ln N_j$	−0.29	−0.25	−0.29	−0.4	−0.4	−0.4	−0.22	−0.25	−0.23
	[0.13]**	[0.14]*	[0.09]***	[0.17]**	[0.21]*	[0.17]**	[0.36]	[0.39]	[0.23]
$B_{ij}\ln A_j$	0.04	0.02	0.04	−0.06	−0.06	−0.06	0.16	0.05	0.12
	[0.14]	[0.14]	[0.12]	[0.17]	[0.17]	[0.17]	[0.28]	[0.38]	[0.20]
$B_{ij}(L_i+L_j)$	0.63	0.56	0.62	0.85	0.85	0.85	−1.29	−0.98	−1.18
	[0.22]***	[0.24]**	[0.18]***	[0.28]***	[0.31]***	[0.26]***	[0.64]**	[0.91]	[0.72]
$BRITAIN_{ij}$	1.88	1.8	1.87	2.88	2.89	2.89	0.13	1.66	0.7
	[0.25]***	[0.27]***	[0.19]***	[0.30]***	[1.00]***	[0.24]***	[0.46]	[3.02]	[0.58]
$FRANCE_{ij}$	2.29	2.17	2.28	2.41	2.41	2.41	0.36	0.48	0.41
	[0.35]***	[0.38]***	[0.28]***	[0.66]***	[0.66]***	[0.26]***	[1.28]	[1.36]	[1.62]
$SPAIN_{ij}$	1.48	1.41	1.48	1.72	1.72	1.72	1.24	2.46	1.69
	[0.44]***	[0.45]***	[0.25]***	[0.58]***	[0.75]**	[0.29]***	[0.89]	[2.56]	[0.96]*
$LANGUAGE_{ij}$	1.44	1.4	1.43	1.38	1.38	1.38	1.36	2.21	1.67
	[0.20]***	[0.20]***	[0.13]***	[0.25]***	[0.66]**	[0.21]***	[0.56]**	[1.75]	[0.57]***
Sample size	15,312	24,806	24,806	3198	24,806	24,806	597	24,806	24,806
	0.39	–	–	0.39	–	–	0.24	–	–
	–	−0.13	−0.015	–	0.0037	0.0006	–	0.67	0.3**

Note: standard errors are in brackets. For MLE, the standard errors are estimated using the Huber–White estimator. ρ is the correlation coefficient between the error terms in the outcome and selection equations.
*Significant at 10%; **significant at 5%; ***significant at 1%.

Columns (2), (5), and (8) of Table 1 report the coefficient estimates of Eq. (1) using Heckman's two-step procedures. The standard errors of the two-step estimates for M&A increase sharply. As a result, none of the estimates in column (8) are statistically significant at the conventional levels. Similarly, columns (3), (6), and (9) report the MLE. While the coefficient estimates from different estimation methods are virtually the same for trade and telephone traffic, they are very different for M&A. This suggests that whether or not M&A flow is observed for a country-pair may not be random. More formally, the parameter ρ at the bottom of Table 1 measures the correlation coefficient between the error terms in the outcome Eq. (1) and the selection equation. The correlation is 0.3 for M&A flows under MLE. It turns out to be the largest in magnitude and statistically significant at the 5% level. In contrast, the correlation coefficient is much smaller and not statistically significant at the conventional levels for trade and telephone traffic.

3. Conclusion

This paper investigates how well geographic, linguistic, and colonial variables explain trade, telephone traffic, and M&A flows. The results suggest that the gravity model fits trade and telephone traffic well. There is also no evidence that the values for trade and telephone traffic are observed non-randomly. On

the other hand, the fit is poorer for the observed sample of M&A flows. The evidence also suggests that missing values in M&A flows are pervasive and non-random, creating a selection bias for the small sample of observed M&A flows.

To use the gravity model to identify M&A's effect on income and productivity, predicted M&A flows from the gravity model would be used as instruments for actual M&A flows. However, in contrast to trade and telephone traffic, because of selection bias in the observed M&A flows, this approach cannot identify the causal effect of M&A flows; the results would be biased.

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