THE SPATIAL RELATIONSHIP OF COMPLEX FOREIGN DIRECT INVESTMENT AND THE EFFECTS OF FOREIGN DIRECT INVESTMENT AND TRADE ON INCOME

by

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DEDICATION

This is dedicated to my loving and generous wife, Amy and to my amazing and entertaining daughter, Calynn.

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I would like to thank my director Carlos Ramírez and committee members Edmund Zolnik and Don Boudreaux for interest and support, especially Dr. Z. for the introducing me to the rigors of geography. I would like express my sincere gratitude for the love and support of my wife, Amy and the motivation provided by my daughter, Calynn. Thanks to the keen insights and generous comments from Andres Marroquin's students from my presentations at Universidad Francisco Marroquin in Guatemala City and at Hillsdale College. Finally, I would like to thank my parents, family, and friends, especially those who suffered through my drafts to offer invaluable comments.

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LIST OF ABBREVIATIONS

BEA	Bureau of Economic Analysis, U.S. Department of Commerce
CEPII	Centre d'Etudes Prospectives et d'Information Internationales
CPI	Corruption Perception Index
FAS	Foreign Affiliate Sales
FDI	Foreign Direct Investment
FE	Fixed Effects Regression Estimation
FKV	Fujita, Krugman, Venables
FR	Frankel and Romer
GDP	Gross Domestic Product
IMF	International Monetary Fund
IV	Instrumental Variable Regression Method
KK	Knowledge-Capital Model of Multinational Enterprises
MNC	Multinational Corporation
MNE	Multinational Enterprise
MNF	Multinational Firm
M&A	Mergers and Acquisitions
N-N	North-North commerce
NEG	New Economic Geography
OLS	Ordinary Least Squares Regression Method
RE	Random Effects Regression Estimation
RHS	Right-hand side (independent) variables
SAR	Spatial Autoregression
TNC	Transnational Corporation
WB	World Bank
WDI	World Development Indicators

Abstract

THE SPATIAL RELATIONSHIP OF COMPLEX FOREIGN DIRECT INVESTMENT AND THE EFFECTS OF FOREIGN DIRECT INVESTMENT AND TRADE ON INCOME

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This paper assesses the implications of spatial dependence of outward FDI flows to clarify the importance and prominence of complex foreign direct investment by multinational enterprises, which are neither purely horizontal nor vertical integration strategies. Empirical tests compare the ordinary least squares, fixed effects, and spatial autoregression techniques for two different models to identify and estimate complex foreign direct investment. The spatial autoregression method directly address spatial correlated residuals while the fixed effect estimation procedure and a fully specified ordinary least squares produce similar regression coefficients. Both models indicate the presence of export platform multinationals while each model has limitations. Then a modified gravity model first assesses the empirical evidence for complementarity between FDI and trade then indicates the predominance of multinational organization strategy. The asymmetric impacts of exports and imports on foreign direct investment are examined, then the effects of both FDI and trade on long-run growth are used to

estimate for the effectiveness of trade to increase income. The direct investment channel is found to be a strong and growing channel of importance for development. Finally, the regional impacts of trade on long-run growth indicates that the spatial advantages of the gravity model can be further exploited using innovations such as an economically-weighted distance variable and regional sub-samples. The findings support broader uses of geographic specifications beginning with a re-estimation of the effect of trade on income. The model is relatively more robust for intra-region trade—underscoring the role of competition in limiting globalization and producing varying effects for the estimates of trade on income.

Chapter 1. Introduction

The complexity of economic arrangements by firms and individuals is a creative expression of survival and the indomitable desire for improvement. I have always wondered about the real differences between peoples and customs in places colored differently while staring at maps for distant places. Through my research and travels, I am simultaneously impressed with the real differences between countries and arbitrary nature of national borders. I have been motivated by my love of numbers and skepticism over data.

The product of these interests has led me to challenge empirical research on the benefits of trade on income to introduce a small amount of spatial complexity and to demonstrate the significance of the investment channel on raising income. These critiques of other empirical findings are intended to assess the extent that their methodology delivers consistent results. The complex nature of multinational firms requires relatively complex methods for estimating the prevalence of the different kinds of integration strategies they might employ. For this problem, a simple spatial econometric method is employed.

Before further describing the contents herein, I need to introduce a few concepts and terms. Foreign direct investment (FDI), or direct investment, is investment in capital structures or a "lasting management interest" in an existing enterprise.[1] Portfolio investment is an investment strategy of risk diversification and profit-seeking without management control or ownership of any capital. The ownership criteria involve active participation in the management and financial monitoring of the firm and are the key difference between portfolio investment and foreign direct investment. From 1978 to 2004, world FDI inflows has increased 6.5 times while world trade has increased 1.7 times and most of this growth occurred in the 1990s (WorldBank, 2006).

In a competitive environment, profitable firms survive and expand domestically, very profitable firms grow and serve foreign markets through exports, and the most profitable firms expand internationally. Foreign direct investment is the outcome of international expansion by profitable multinational enterprises (MNEs).[2] Multinational Enterprises (MNEs) are firms with production facilities in more than one country. Production refers to any phase of business including manufacturing, marketing, or headquarters services.

MNEs have two main motivations: market access or comparative advantage; there are two main types of multinationals: horizontal and vertical. The distinction between horizontal and vertical multinationals rests on the intended destination market for the product. The horizontal MNE is motivated by "market access." Affiliate production of the multinational displaces exports to serve the host country's market. Horizontal FDI consists of investments that duplicate facilities and operation in several countries; the

1 Foreign direct investment (FDI) is used interchangeably with "direct investment" when international investment flows is implied.
2 Alternative terms for MNEs are multinational corporation (MNC), transnational corporation (TNC), or multinational, though I have used MNE.

host country is the destination country. Such investment is most likely between similar countries. A vertical multinational produces abroad to take advantage of the comparative advantage for each country and for each step along the chain of production. The host country is usually not the destination country for final consumption. Differences in production costs between countries generates vertical direct investment, thus it is more likely between economically different countries, especially in terms of wage rates. The distinction between horizontal and vertical MNEs provides a useful classification method: vertical MNEs export goods for sale or further processing and horizontal MNEs displace trade (Markusen and Maskus, 2001). Multinationals can be primarily viewed as organizations that transfer knowledge-based goods and may be classified as horizontal or vertical. However, there are natural limits to the extent of vertical FDI.

The gravity model is the main empirical tool for trade economists. It posits a negative relationship between bilateral trade and distance between two countries and a positive relationship between bilateral trade and country size. As distance increases between any two countries they could become less similar leading to more possible profitable exchanges, a kind of complementarity. However, as distance increases transportation costs increase and familiarity decreases—leading to less trade. In numerous empirical tests, the latter effect, a kind of substitution effect, dominates. Trade decreases as distance increases. The gravity model is used to estimate the effects of trade on income as well as location choice of MNEs relative to other sites.

The data used in this analysis are all publicly available and are mainly drawn from the World Bank's World Development Indicators and the International Monetary Fund's

Direction of Trade Statistics. Distance data and longitude and latitude data for all countries are from the Centre D'Études Prospectives et D'Informations Internationales (CEPII) (Mayer and Zignago, 2002).

The primary effects of MNEs are on production, exports, and employment in the host country. They raise GDP and wages, but the secondary and tertiary effects may involve the development of industry linkages and technological spillovers. Spillovers might come from the increased economic competition, copying the methods of the MNE by the host country-firm, or from labor turnover between foreign and host firms.

The second chapter assesses the implications of spatial dependence of outward FDI flows to clarify the importance and prominence of complex foreign direct investment by multinational enterprises, which are neither purely horizontal nor vertical integration strategies. Empirical tests compare the ordinary least squares, fixed effects, and spatial autoregression techniques for two different models to identify and estimate complex foreign direct investment. The spatial autoregression method directly address spatially correlated residuals while the fixed effect estimation procedure and a fully specified ordinary least squares produce similar regression coefficients, both models indicate the presence of export platform multinationals even though each model has limitations.

The next chapter tests uses a modified gravity model to first assess the empirical evidence for complementarity between FDI and trade, which indicates the predominance of multinational organization strategy. The asymmetric impacts of exports and imports on foreign direct investment are examined, then the effects of both FDI and trade on long-run growth are used to estimate for the effectiveness of trade to increase income.

The direct investment channel is found to be a strong and growing channel of importance for development.

The fourth chapter tests for the regional impacts of trade on income by first using the gravity approach to development instrumental variables to disentangle the endogeneity between trade and income. The spatial advantages of the gravity model can be further exploited using innovations such as economically-weighted distance variable and regional sub-samples, which enable regional estimates to compare the relative strengths and weaknesses of the gravity model. The findings support broader uses of geographic specifications beginning with a re-estimation of the effect of trade on income. The model is relatively more robust for within-region trade—underscoring the role of competition in limiting globalization and producing varying effects for the estimates of trade on income.

These studies move from the initial consideration of the location choice of MNEs subject within an environment of complex integration strategies to examine the spatial dependence of direct investment. Then the effects of the direct investment on income, with its interactions with international trade, identify an important channel for potential growth for developing and developed countries. However, the spatial correlation of these inflows of direct investment leads to the final investigation: the spatial variation of the benefits of trade to determine that some regional effects dominate and even overturn the aggregated results for the benefits of trade in raising income. While these regional variations attest to the leave additional questions, they attest to the dangers of spatially aggregated measures to explain in simple relationships, even those of the benefits of trade. These studies are a grateful expression of a desire to extend our understanding of complex economic behaviors in a spatial environment that rests on the creative and provocative approaches of others.

Chapter 2. Complex Integration Strategies of U.S. Multinational Enterprises: A Spatial Econometric Approach to Location Theory using U.S. Direct Investment Outflows

1. Introduction

> ...Cities, local specialization, and trade cannot arise in the competitive equilibrium of an economy with a featureless space (Fujita and Thisse, 2002, p 16).

Spatial agglomeration is not possible with the featureless landscape of the Arrow-Debreu model—the competitive model cannot be used as a basis for studying the spatial economy (Fujita and Thisse, 2002, p 26). When activity is perfectly divisible and resources are homogeneous, then autarky results with a competitive equilibrium. With perfect competition and indivisibility, then economic activity is compressed to a point—it becomes aspatial. Starrett shows how the Arrow-Debreu model cannot generate spatial clusters and trade under perfect competition due to indivisibilities that will generate transportation costs. Once indivisibilities require agents to take up space, transportation costs are generated, yet the positive price gradients simultaneously induce producers of different regions to relocate to seek higher revenue and consumers to relocate to seek lower prices. Some agents will always want to relocate due to the positive costs of trade. Starrett's Spatial Impossibility Theorem states "Consider an economy with a finite number of consumers and firms. If space is homogeneous, transport is costly, and preferences are locally unsatiated, then there is no competitive equilibrium involving transportation." (Starrett, 1978), quoted from (Ottaviano and Thisse, 2002, p 2572).3 Even in homogeneous space, if economic agents use land as an input, then economic activity will form into clusters. "It is almost impossible to think of a spatial economy in which agents are price-takers and to derive relevant and plausible results at the same time about the distribution of economic activities over a homogeneous space" (Fujita and Thisse, 2002, p 26). Isard contends that "the existence of physical space implies immobility, limited competition and spatial inelasticity (or negative spatial elasticity). Thus, the generally accepted principle of pure competition is not applicable to the analysis of spatial economic processes" (Isard, 1949, p 490).

To understand the spatial distribution of economic activity there are a few possible additional assumptions required of the researcher.

> (I)t follows from the spatial impossibility theorem that we must assume either that *space is heterogeneous* (as in the neoclassical theory of international trade or in land use models a la von Thünen), or the *externalities* exist and are many (as in modern urban economics), or that *markets are imperfect* (as in spatial competition theory or in economic geography) (Ottaviano and Thisse, 2002, p 2572).

If space is assumed to be heterogeneous, then it relies on differences of first nature to explain agglomeration; broad geographic conditions must explain spatial clustering of

3 The Spatial Impossibility Theorem can be stated as "No competitive equilibrium involving trade across locations exists in homogeneous space" (Fujita and Thisse, 2002, p 28).

economic activity. Neoclassical theory on international trade demonstrates the catallatics of exchange when space is not homogeneous, but differences of first nature are implausible as the sole determinant of spatial agglomeration—geography does not fully explain economic variation. Second nature, the spillovers of other firms generate increasing returns to scale, sufficiently explains the distribution of economic activity in both homogeneous and heterogeneous space. Increasing returns to scale are essential to explaining the economic distribution of activities—the folk theorem of spatial economics.

A combination of horizontal and vertical foreign direct investment known as complex foreign direct investment plausibly explains much of the multinational enterprises' (MNEs) activity as most firms optimize between both horizontal and vertical motivations.[4] Helpman modeled the fragmentation of the production process under the assumption of zero transportation costs to generate vertical MNEs that are motivated the comparative advantage motive (Helpman, 1984). Meanwhile, Markusen modeled horizontal MNEs that investment in production facilities to foreign countries to serve the foreign market—the market access motive (Markusen, 1984). Both Helpman (1984) and Markusen (1984) model investment in foreign production as an alternative to exports. Motivations are often mixed rendering strict delineations of motivations a more productive theoretical device than an empirical one (Lipsey, 2002). Complex foreign direct investment (FDI) strategies fragment production between the home and host country to serve the home market or a "third" market.

4 Multinational enterprise (MNE), multinational corporation (MNC), and transnational corporation (TNC) are interchangeably used in the literature, however "MNE" is used here.

MNEs are generally larger, more productive, and pay higher wages than domestic firms in the same industry (Antràs and Helpman, 2004; Lipsey, 2002; Navaretti and Venables, 2004). However, MNEs tend to employ more capital-intensive technology than domestic firms. Direct investment by MNEs has been moving away from primary sector to manufacturing and services; inward FDI stocks in the primary sector in OECD countries fell from 15.2 per cent of FDI stocks in 1982-1986 to 5.7 per cent in 1998-2000 (Navaretti and Venables, 2004, p 22). The distribution of world FDI stocks is 50.3 percent to services, 41.6 to manufacturing and 8.1 for primary goods (ibid). Most FDI is concentrated in skilled-labor and technology intensive industries and the broad sectors are characterized as requiring large investments in research and development and employing a large share of professional and technical workers in the production of technically complex or differentiated goods (economies of scale) (Navaretti and Venables 2004, p 10).

This paper assesses the implications of spatial dependence of outward FDI flows to clarify the importance and prominence of complex foreign direct investment by multinational enterprises, which are neither purely horizontal nor vertical integration strategies. Two previous articles attempt to empirically identify the presence of complex FDI and the accompanying MNE organizational structure, (Baltagi, et al., 2007; Blonigen, et al., 2007). The identification techniques differ considerably and this paper evaluates each of them. The theoretical model of Grossman et al. (2004, 2006) is applied to the spatial autoregressive econometric technique of Blonigen et al. (2004, 2007) and compared to Baltagi et al. (2007), which is based on Markusen's Knowledge-Capital

(KK) model with modifications to the time period, panel of countries, and institutional constraints to determine the superior empirical techniques for identifying and estimating third country effects of direct investment.[5] Typical bilateral determinants of foreign direct investment such as market size, human capital, and institutional constraints are included for the host country and then expanded to include "third countries" to assess the prominence of complex FDI, the relative limitations of ordinary least squares (OLS), fixed effects (FE), and spatial autoregressions (SAR) regression techniques between two different empirical specifications. The two models produced consistent results, except for the fixed effects approach which cannot use country characteristics which are time invariant. Both models for OLS and SAR techniques indicated the presence of export platform MNEs.

The next sections review the relevant literatures on location theory, spatial effects, new economic geography, new international economics, and the theory of multinationals. Section 3 proposes a theoretical model that incorporates spatial dependency in an environment of multinational investment; section 4 details the empirical techniques and data sources. Section 5 presents the empirical estimation results and section 6 concludes.

2.1 Literature Review

Research into the spatial arrangement of economic phenomenon follows from the traditions of economists, geographers, mathematicians, and landed gentry. Location

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5 Depending on the number of countries and stages of production, there is no limit to the number of the types of complex FDI. "Third" markets or countries refers to all other countries than the home and host countries.

theory primary developed within the German-speaking world where it remained for nearly a century and subsequently, it most readily attracted the imagination of geographers. A few economists, such as Hotelling and Tiebout, used models of spatial competition, but it was not until the 1990s that Krugman and Venables developed a model with spatial interactions within a framework theoretically acceptable to economists under the moniker of "New Economic Geography" (NEG) (Fujita, et al., 1999; Hotelling, 1929; Krugman, 1991; Marshall, 1961; Tiebout, 1956). NEG borrowed from the Dixit-Stiglitz monopolistic competition model in much the same way that Markusen and others did in developing New Trade Theory and the theory of multinationals (Dixit and Stiglitz, 1977; Helpman, 1984; Markusen, 1984). Finally, the spatial econometric literature draws from even more diverse disciplines including evolutionary biology and epidemiology (Anselin and Florax, 1995; Moran, 1950).

The first major developer of location theory is recognized as Johann Heinrich von Thünen whose detailed records of agricultural land use inspired his ideas on land use and wage theories. Von Thünen's model of the location of the city in a circle that is surrounded by agricultural land made a profound contribution in terms of marginal analysis and in understanding land use and location theory. He identified the primary centrifugal forces of high land rents and high food prices and centripetal forces of economies of scale and inter-industry linkages and the spillovers at work that are necessary to explain city formation (Fujita and Thisse, 2002). However, von Thünen assumed the existence of the town and derived the ring pattern of land-use gradients around the town as opposed to deriving the existence and location of the town from the land-use gradients (Ottaviano and Thisse, 2002). Finally, Von Thünen's work on marginal productivity preceded Menger's work on marginal utility by 50 years and Thünen might be correctly viewed as an important precursor to the marginal revolution, though not as a founder of marginalism as stated by Samuelson (Samuelson, 1983).[6]

Alfred Weber, the younger brother of Max Weber, discovered the *dominant place* of industrial location is the solution to the minisum problem (Ottaviano and Thisse, 2002, p 2570). The minisum problem minimized "the weighted sum of Euclidean distances from that plant [firm] to a finite number of sites corresponding to the markets where the plant purchases its inputs and sells its outputs" (ibid). Like the zero-profit assumption for atomistic markets, firms are likely to settle where others already exist and thus generate what Weber called an "agglomeration" (ibid).

August Lösch and Walter Christaller pioneered central place theory (Fujita and Thisse, 2002, p 351). However, Christaller's and Lösch's theory only explained the agglomeration of the same goods (sales), not different goods. "Lösch showed that a hexagonal lattice is efficient; he did not describe a decentralized process from which it might emerge" (Fujita, et al., 1999, p 27). Central place theory is not a causal model, but a descriptive one.

Some of the earliest spatial models of spatial interactions go to Alfred Marshall's explanations of industrial districts as a result of knowledge spillovers, advantages of thick markets, and backward and forward linkages, according to (Fujita, et al., 1999; Marshall,

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6 In fact, Menger appears to have been completely unaware of Thünen's work see Bloch, H.-S. 1940. Carl Menger: The Founder of the Austrian School. *The Journal of Political Economy*. 48(3): 428-433. p 428-9 and von Hayek, F.A. 1934. Carl Menger. *Economica*. 1(4): 393-420. p 396.

1961, p 4-5). Linkages have been extensively analyzed within the new economic geography literature, while the first two explanations have been largely ignored due to modeling difficulties. Marshall understood that a dynamic analysis required choosing time or space and he thought time had a greater importance. (Isard, 1949, p 476).

Harold Hotelling showed the importance of strategic interactions for spatial competition, which is by nature oligopolistic (Hotelling, 1929). Hotelling's works have been more readily applied to game theory than economic geography.

By the 1970s, locational analysis in international economics was mainly through the OLI approach—ownership, location, and internalization as developed by John Dunning and Williamson's work on transaction costs (Dunning, 1970; Williamson, 2002). Firms decide whether or not to internalize the transaction through opening up foreign affiliates based on the ability to fully appropriate rents through arrangements with external firms. This framework has been extended to address issues of hold-up issues and agency theory.

Walter Isard introduced the Anglophone world to the German contributions to location theory (Isard, 1949). David Ricardo's theories surpassed those of his contemporary von Thünen, obviating all spatial considerations due to assuming different fertilities of land and obscuring transportation costs from other costs (Fujita and Thisse, 2002, p 11). Isard first objects to the simultaneous implicit treatment of transportation costs and the explicit treatment of production costs. "For a balanced treatment, the particular effects of transport and spatial costs in separating producers from each other must be considered. They are too vital to be sidestepped through implicit treatment, as has been done by Hicks and others" (Isard, 1949, p 478). Isard contests that trade theory is synonymous with the general theory on location and space-economy since neither trade nor location can be explained without the other (Isard 1949, p 505). "Modern general equilibrium theory is a special case of this theory, in which transport costs are taken as zero and all inputs and outputs are viewed as perfectly mobile; international trade theory, in its traditional scope, is also a special case of this theory" (ibid).

2.2 Spatial Effects: What are they?

There are two broad classes of spatial effects: spatial dependence and spatial heterogeneity, according to Anselin and Florax (Anselin and Florax, 1995). The first, spatial dependence implies a spatial structure underlying the spatial correlation. Spatial correlation may be autocorrelation or cross-correlation, where "the strength and specification of the spatial dependence are determined by absolute and relative location (topology and distance)"(Anselin and Florax, 1995, p 4). Some simple gravity models that incorporate bilateral distance to explain trade have penetrated mainstream economics while those dealing with more complex spatial interactions have rarely progressed beyond the subcategory of economic geography. The relevance of spatial dependence may be displayed through dependent variables or the error term. In the former case (substantive spatial dependence), the main interest is the interaction of spatial dependence such as studying the spread of new technology over a geographic space. Alternatively, the spatial dependence between omitted variables will show up in the error terms and this is known as nuisance dependency. Spatial heterogeneity, also known as spatial nonstationarity, deals with spatial or regional differentiation—the second type of spatial effect. "This is a special case of the more general problem of structural instability, but where the structure pertains to *spatial structure*, i.e., to specific locations or sub regions in a data set." (ibid). In fixed effects estimation, each location would have its own functional specification and for random effects all locations are assumed to conform to the same encompassing model and region-specific characteristics are conceptualized as random deviations from the overall mean.

Spatial dependence and spatial heterogeneity both violate Gauss-Markov assumptions used in ordinary least squares (OLS) regression analysis. Explanatory variables are not necessarily fixed in repeated sampling, nor is there necessarily a linear relationship across all sample data relationships (LeSage, 1998, p 2).

There are several tests against spatial autocorrelation. The most widely used test remains to be Moran's I, while other tests are based on spatial Lagrange Multiplier (LM) tests (error, lag, autoregressive, and moving average).[7] Using Monte Carlo experiments Anselin and Florax test the relative strengths of each of these tests to support the strength of Moran's *I*, albeit the "statistic provides little insight into which form of spatial dependence is the correct alternative hypothesis" (Anselin and Florax, 1995, p 7).

Moran's *I* tests for spatial dependence using the aggregates of correlations and their spatial lags much like the Durbin-Watson test for time series data by testing the co-movements of residuals with those of neighboring or lagged time periods (Moran, 1950). "...The Moran captures co-movement with neighboring states (spatial lags)" (Aroca, et

7 For a more detailed list of equations and assumptions, see Appendix 1.

al., 2005, p 8). In interpreting Moran's *I* statistic, it is compared with its theoretical mean and using a normal approximation where, "a positive and significant Moran suggests positive spatial correlation (clustering of similar values), whereas a negative spatial correlation implies clustering of dissimilar values." (Aroca, et al., 2005, p 8). Sources of spatial interactions include spillovers, externalities, industrial linkages, regional issues, and competition between cross sectional units (Kapoor, et al., 2007).

2.3 Empirical Tests of Spatial Dependence

Quah (2002) uses a spatial Neoclassical growth model where knowledge accumulation is the engine of growth. The distribution of knowledge is a result of knowledge spillovers across geography while the optimal knowledge-accumulation decisions "determine the distribution of knowledge used across space and time. The resulting pattern of economic activity is not concentrated on discrete isolated points, but is instead dynamically fluctuating..."(Quah, 2002, p 251).

A spatial analysis of growth and income in Mexico during a period of trade liberalization is studied by Aroca et al. (Aroca, et al., 2005). The standard convergence approaches [Sala-i-Martin and Barro] offer point estimates of the central tendency of the data toward convergence or divergence. However, these approaches conceal vast amounts of information on the dynamics of relative income movements among states and do not shed light on the spatial dimensions of growth (Aroca, et al., 2005, p 6).

Aroca et al. follow the lead of Quah (1993; 1997) by constructing Markov transition matrices which "tabulate the probabilities of states moving among a finite number of intervals of the national income distribution and hence characterize the dynamic patterns of relative income movements" (ibid p 6). Furthermore, Quah proposes the use of kernel density estimates to approximate a continuous income distribution. Aroca et al. (2005) follow this procedure for periods before and after trade liberalization in Mexico to discover evidence of spatial dependence, where income levels or growth rates are correlated by geographic location (p 6).

Simple OLS estimates need to be derived from a model that is consistence with the assumptions of Gauss-Markov, yet the presence of spatial dependence or spatial heterogeneity require alternative estimation procedures where maximum likelihood estimations are the most popular.

Coughlin and Segev (2000) are the first to utilize a spatial econometric technique to examine FDI behavior in their article on U.S. FDI across Chinese provinces from 1990-1997. They test both a spatial autoregression and a spatial autocorrelation model (spatial error model) and find that using the spatial autoregression model there is an equi-proportional to slightly more than proportional increase in FDI. The findings of a positive spatial error for evidence of agglomeration economies reconfirms Tobler's first law of geography: everything is related to everything else, but near things are more related than distant things.(Tobler, 1970)

2.4 The (Re-)Discovery of Geography - Thanks to Krugman

Following the development of the "core-periphery models" by Krugman and Venables (1990), Fujita, Krugman, Venables (FKV) are credited with reviving interest in economic geography through tractable models based largely on the Heckscher-Ohlin model (factor proportions) of international trade and the Dixit-Stiglitz model (Dixit and Stiglitz, 1977; Fujita, et al., 1999).[8] FKV combined Lösch's and Christaller's insights into a micro-based model, namely the core-periphery model. In the core-periphery model, the location of firms, N, is a function of relative costs, markets size, and trade costs. N-g(C, S, t). Costs are assumed to be symmetric (C=1). Trade costs decrease to such a low point that they become insignificant and then induce firms to invest. The size of the market is important due to the market access motive and as a result, small countries will be relatively worse off when there is trade liberalization. However, as trade costs decline the advantages of market access will again dominate. There are five essential elements for NEG: increasing returns to scale internal to the firm, imperfect competition, trade costs, endogenous firm locations, and endogenous location of demand (Head and Mayer, 2004, p 2614).

A pure agglomeration model includes linkages. "the main difference [between core-periphery and agglomeration] stems from the mechanism behind agglomeration, which relates to the impact of firms' location on costs and market size in the area of location" (Braunerhjelm and Svensson, 1998, p 103). N*=g(C(N),S(N), t). The distribution of firms (N*) depends on productions costs and market size, which depend on the location of firms into these markets.

8 In contrast to the Neo-Walsian (integral and ergodic) approach of NEG, Potts takes a non-integral approach Potts, J. (2000). *The New Evolutionary Microeconomics: Complexity, Competence, and Adaptive Behaviour*. Cheltenham, UK: Edward Elgar.

While FKV deserve credit for popularizing the spatial approach to economic activity due to its tractable model, very few single insights are new. The insights of the core-periphery model and others in NEG are usually classical: Smith, Cantillon, Mill, von Thünen, Weber, Lösch, Marshall, and Hotelling to name a few certainly predate FKV. The tension between transportation costs and increasing returns to derive city formations and determine the optimal size is critical for NEG, but its "rediscovery" overstates what was not really lost.

In measuring an agent's relative importance over a defined space, the two main measures are location quotients and market potential. Hildebrand and Mace (1950) employ location quotients to define the relative importance of industry employment which in turn, indicate industrial clusters.[9]

Location quotients may be used for any economic activity including employment, output, investment, et cetera. A locational Gini-coefficient—a modified location quotient was developed by Krugman (1991) and used by Modén (1998) to identify industry and geographic clusters across the 24 provinces of Sweden.

The "market potential" concept is derived from Weber's minisum location problem where weighted distances are minimized to determine the dominant place and profit maximizing firm integration strategy. The inverse of the arc distance is weighted

9 "Formally, the location quotient is the numerical equivalent of a fraction whose numerator is employment in a given industry in the subject economy relative to total employment in the subject economy, and whose denominator is employment in the given industry in the benchmark economy relative to total employment in the benchmark economy. A priori, a location quotient of 1.00 means no greater relative specialization in the subject economy than in the benchmark economy, for the particular industry. In each industry, values significantly below 1.00 indicate much greater relative specialization in the benchmark economy; or if well over 1.00, much greater relative specialization in the subject economy." Hildebrand, G.H., and Mace, A. 1950. The Employment Multiplier in an Expanding Industrial Market: Los Angeles County, 1940-47. *The Review of Economics and Statistics*. 32(3): 241-249.

by the total market size of each and every third country.[10] Market potential is useful to demonstrate additional market demands that are not accounted for in bilateral models. Harris (1954) developed the modern market potential measure in studying economic flows within Los Angeles.

International market potential can be disaggregated by industry and based on market-clearing assumptions, a price index for each industry and country pair can be computed to form the real market potential. While caution is urged in using a nominal market potential, which does not include any measure of price variation in each national economy, it is unnecessary when using aggregate data. In addition, the third country consumer demand is assumed to be neutral to consuming imported goods and locally produced goods from foreign affiliates.

Head and Mayer (2004) develop a Krugman Market Potential model based on Krugman (1992) that can be shown to be derived from Harris (1954) but is theoretically derived and includes competition factors and market access. Head and Mayer (2004) derive a market potential measure for country-pairs using detailed industry data and based on the NEG model where profits are a mark-up of costs. The micro-based model equalizes prices spent by consumers in one region to total value of imports using a price index (from FKV 1999) and the number of suppliers (Head and Mayer, 2004, p 2618). A price index is necessary to generate a real market potential measure and while caution is urged in using a nominal market potential since it does not include an adjustment for variation of the price index.

10 Assumptions on elevation are required and some measures are less accurate for shorter distances.

2.5 Theory of Multinationals

Models of endogenous location choice of multinationals are primarily based on the foundational works by Markusen (1984) and Helpman (1984). Agglomeration or clustering results from the "type and degree of scale economies in production, dispersion of specific skills, and externalities originating in learning, innovation, and network economies" (Braunerhjelm and Svensson, 1998, p 99). Markusen describes the knowledge-capital model as capturing, "the notion of horizontally integrated firms that undertake the same activity in multiple countries but excludes any motive for vertical specialization" Three key assumptions for Markusen's knowledge capital model are fragmentation, skilled-labor intensity, and jointness (Markusen, 2002, p 129). Fragmentation asserts that "the location of knowledge-based assets may be fragmented from production" (ibid). Fragmentation is the technology transfer cost or the ease of supplying services to a foreign plant, which is the key concept to explain vertical multinationals (Markusen, 2002, p 129-130). Skilled-labor intensity directly affects the production of knowledge-based assets. Thirdly, "jointness" is public nature or spillover benefits of using knowledge-based assets as inputs into multiple production facilities. "Jointness is the key concept explaining motives for horizontal multinationals" (Markusen, 2002, p 129).

Multinationals can be primarily viewed as organization which transfer knowledge-based goods and may be classified as horizontal or vertical. Horizontal MNEs have a strong market access motive and exist when the fixed costs of plant set-up are low, host country markets are large, and transportation costs are high. Vertical MNEs seek to maximize comparative advantage of each country along the production chain and result from the unbundling of headquarter services and production, high fixed costs of plant set-up, low transportation costs. “horizontal affiliate production substitutes for trade while vertical or export-platform production complements trade. Horizontal affiliates arise between large, similar countries, while vertical and export platform production arise between a parent in a high-cost country and a low-cost developing country” (Ekholm, et al., 2003, p 25).

In addition to pure horizontal and pure vertical FDI, there are at least two varieties of partial globalization when there are more than two countries: export platform and vertical specialization with agglomeration. The kinds of complex FDI depend on the number of countries, stages of production, and number of inputs. The four types that Baltagi et al. (2006) studied are presented in table 1 below.

Table 1. Types of MNE Integration Strategies

Type	Production	Exports
Horizontal (h)	d, i	d, j
Export-platform (h)	d, i	i, j
Vertical (v)	i, j	i, d
Complex Vertical (v)	i, j	j, d

d, i, j represent the home or domestic country (d), host country (i), and third country (j).

These types are common to Blonigen et al. (2007) and Grossman et al. (2006), while Yeaple (2003) and Ekholm et al. (2003) only have three kinds of MNEs.[11] Country *i* is

11 Grossman et al. (2006) have up to six kinds of MNEs including the four types presented here. Yeaple (2003) and Ekholm et al. (2003) only have three kinds of MNEs.

the host country, country *d* is the home or domestic country, while country *j* is the third country. Headquarters are in the home country (*d*). The broad category of MNE, horizontal or vertical are "h" and "v" respectively. Production facilities (Plants) are located in both of the countries listed and exports are listed by the source and the destination countries.

For example, (pure) horizontal MNEs produce in both *d* and *i* and exported from *d* to be consumed in *j*. Export-platform FDI is defined as production in *d* and *i* and exported from *i* to be consumed in *j*. The two h-types serve the foreign market, *j*, while the two v-types serve the home market, *d*.

At some level, all production is export platform—everything is transported for consumption elsewhere. I should expect to see less of it in large economies. (Ekholm, et al., 2003) show this when discussing the differences between treating the European Union as a single country or not. In particular, if the EU is a single country, then investment in Irish production to serve the Germany market is horizontal. Conversely, it is considered export platform if Ireland and Germany as not the same country. The implication of which is that much of the export platform FDI will not show in the data where the EU is not disaggregated. "The countries which display export-platform sales most clearly are not developing countries, but smaller countries inside the EU." (Ibid p 4).

Using a familiar three-country model with two identical countries "East" and "West" which comprise the "North" and a single "South" country, Yeaple (2003) is interested in the complementarity between northern and southern FDI (p 299). There are two inputs to assemble the final differentiated final good, where the North and South each have a comparative advantage in the production of an input and all consumption takes place in the North. The South is relatively low-wage and the North is relatively high-wage and headquarters services are all located in the North. The resulting form of MNE depends on factor-price differentials, transportation costs, and fixed costs of establishing affiliates outside of the home country. Yeaple (2003) supports the empirical findings of Brainard and Riker (1997) and Slaughter (2000) of complementarity of investments in the North and South (Yeaple, 2003, p 312).

Ekholm et al. (2003) also present a three-country model with regions of North, East, West, and South like Yeaple (2003) and Markusen (1986). Ekholm et al. (2003) present a duolopoly model where an intermediate good must be produced in the home country, but may assemble the final product in one or more other countries. Again, the organizational outcomes reflect differences in variable transportation costs and fixed costs of foreign investment. Ekholm et al. (2003) find that export-platform FDI is preferred "if the cost disadvantage of the north is (a) large relative to the cost of shipping final output... and (b) large relative to the cost of shipping components and the per-unit fixed costs of a second plant…, but (c) not large relative to the costs of shipping components to S" (p 25).

Grossman et al. (2004, 2006) differ from Yeaple and Ekholm et al. (2003) by developing a more general model where productivity levels vary across firms and that can produce a wider variety of integration strategies in equilibrium (p 218).

In contrast to previous papers, Baltiagi et al. (2007) explicitly estimate the complex FDI model using the Knowledge-Capital (KK) model and in turn, use the same kinds of measures as (Carr, et al., 2001) in their estimates of the knowledge capital with two countries. Baltagi et al. use a three country model, yet they use US outward foreign direct investment (FDI) stocks and foreign affiliate sales (FAS) at the industry level as a function of relative factor differences, and allow spatial interactions of the explanatory variables and the spatial autoregressive errors. Spatial autoregressive variables are used to capture third country effects while spatially correlated errors are used to account for transmission shocks between countries using a spatial panel data generalized moment estimation as outlined by (Kapoor, et al., 2007) and (Baltagi et al. 2007, p 265).

Baltagi et al. (2007) find support for the presence of complex FDI patterns and importance of third country effects (p 262). "In particular, we find that the bilateral and third-country effects of changes in skilled and unskilled labor endowments tend to be substitutes for vertical and complex vertical FDI" (ibid, p 273).

Following Coughlin and Segev (2000), Blonigen et al. (2007) use the coefficient estimates of two key variables in maximum likelihood estimation of a spatial lag model to deduce the presence of four kinds of MNEs. The spatial lag method is parallel to a lagged dependent variable in time series analysis and identifies the correlation between the FDI in proximate regions (p 1306).[12] Blonigen et al. (2007) find that a country-level fixed effects estimator can sufficiently minimize spatial effects (ibid, p 1316). Secondly, omitted and significant trade costs can exaggerate the effect of surrounding market potential on MNE activity (ibid, p 1320). Finally, only after attempting to account for

12 A (row standardized inverse) distance weight matrix was chosen.

trade costs by using a sub-sample of European-OECD countries, is clear evidence of export platform FDI found (ibid, p 1322).

3.1 Theoretic Model

The model is a three-country, two-industry, two-stage production function with two goods based on the model proposed by Grossman et al. (2004, 2006). The homogeneous good x_0 is competitively produced, but not exported and the differentiated good x_j is traded, but subject to monopolistic competition. The three countries are divided between a developed, capital abundant, high wage, large market North (N), which is comprised of two identical countries East (E) and West (W), and the relatively underdeveloped, labor abundant, low wage, and small market South (S). Goods are first produced then assembled in any country, but in keeping while the KK model, headquarter services are restricted to the North. Firms choose to serve home and foreign markets via exports or FDI. Foreign production in S has lower fixed and variable costs, but higher transportation costs (than N). Horizontal MNEs invest in FDI to serve the foreign market, while vertical MNEs use the relatively low production costs in S to serve the home market.

The household utility function is derived from a CES utility function and is given by equation 1.

$$(1)\ U = x_0 + \sum_{j=1}^{J} \frac{1}{\mu_j \alpha_j^{\alpha_j}} X_j^{\mu_j}, 0 < \mu_j < 1$$

Households consume both the homogeneous good x_0 which is produced under competitive conditions and an index of differentiated goods Xj from industry j ∈ {1, ..., J}. The elasticity of substitution between consumption is constant μ_j from each industry j at any two points in time. For any industry j, the elasticity of substitution between any pair of goods is 1 = (1-α_j). Assume $\alpha_{j>}$ $\mu_{j,}$ or that the elasticity of substitution is greater between the same goods of different brands than between outputs of different industries.

The index of differentiated goods, X_j, is given by equation 2. The consumption of good x is industry j for the variety or brand i is represented by $x_j(i)$, where n_j is the number of varieties in that industry (Grossman, et al., 2004).

(2) $X_j = \left[\int_0^{n_j} x_j(i)^{\alpha_j}\, di\right]^{1/\alpha_j}, 0 < \alpha_j < 1$

To determine the wages in the North and South, first assume that workers in the North are more productive in producing the homogenous good x_0. Due to the differences in productivities there are different wages in the North versus the South. Let one unit of labor produce one unit of x_0 in the North, but 1/w>1 units of labor are needed in the South to produce one unit of x_0. Assuming the homogeneous good is produced competitively in equilibrium in each country, then the price of x_0 is used as the numeraire. Wages w^ℓ in the North are equal in East and West and higher than the wages in the South, w_e=w_w=1>w_s, and 1/w units of labor in the South is needed to produce one unit in the South.

Congruous to the Knowledge-Capital (KK) model, producers of differentiated products are assumed to only come from one of the Northern countries where they maintain their headquarters. Unlike Yeaple (2003) and Ekholm et al. (2003), productivity is allowed to vary by industry. Productivity in each industry j is draw from a cumulative distribution function $M_j(\theta)$. The firm's production function $\theta F_j(n,a)$ is characterized as an increasing and concave function with constant returns to scale elasticity of substitution in industry j with productivity θ. In the two-stage production, intermediate inputs, n, may be produced at a different location than final assembly, a. The elasticity of substitution between n and a is less than or equal to one Gross et al. 2004, p 6).

3.2 Costs

The total production cost for each industry j, c_j, is the sum of the cost of production p_n and assembly p_a including any transportation costs, where the unit production cost function is $c_j(p_n, p_a)$. Since productivity θ varies between firms, the variable unit cost is given by $c_j(p_n, p_a)/\theta$.

As Markusen(2002) and others have observed there is an additional monitoring cost when production is fragmented.[13] The fixed cost of monitoring and communication when production n takes place outside of the home country, is denoted by h and the fixed cost for FDI of assembly is f. Both fixed costs, f and h, are assumed to be the same for either the North or the South. Transportation costs are assumed to be iceberg, such that some of the good "melts" during transit. The amount of intermediate and final goods shipped t_j, must be greater than one to generate one unit of assembly or consumption, thus t_j>1. The variable unit cost is therefore $t_j c_j(p_n, p_a)/\theta$. Using the costs in the North

13 [Markusen is agnostic about the effects of distance since transportation costs increase with distance, but so do monitoring costs. In contrast, Grossman et al. (2004, 2006) have monitoring costs as fixed. See Markusen 2002 p. 226 and Carr et al. p 699]

as numeraire, firm strategies with production and assembly in the North would be $t_j c_j(1,1)/\theta$ and for both production and assembly in the South would be $t_j c_j(w,w)/\theta$. The variable cost of production in the West and assembly in the South (to serve the North market) would be $c_j(1, t_j w)/\theta$ and finally, the variable cost for production in the South and assembly in the West would be $c_j(t_j w, 1)/\theta$ (Grossman, et al., 2004, p 6-7). In sum, there are production may be subject to transportation costs and two kinds of fixed costs (k) for communication and monitoring (h) and establishing foreign affiliates for assembly (f).

3.3 Market Demand

Assuming monopolistic production in each for country for the differentiated good, the CES demand function faced by the firm is given in equation 3.

$$(3)\quad \begin{array}{l} x^{\ell} = \alpha^{-\alpha/(1-\alpha)} Y^{\ell}\left(p^{\ell}\right)^{-1/(1-\alpha)}, 0 < \alpha < 1 \\ \ell \in \{E, W, S\} \end{array}$$

The aggregate demand level in country ℓ is Y^{ℓ} and p^{ℓ} is the delivered price level. This model differs significantly from Grossman et al. (2004, 2006) where the aggregate demand level in country ℓ is the sum of domestic market demand and the inverse-distance weighted demand levels of the other two countries.

3.4 Profits

The profit maximizing strategy for each firm will depend on the transportation costs and fixed costs of production. Firms charge a mark-up price of 1/α of the per unit variable cost. Profits are given by equation 4, where $\overline{Y}$ is the total market demand, $\Theta \equiv \theta^{\alpha/(1-\alpha)}$ is a transformed measure of the firm's productivity, tc is the per unit variable cost of production and transportation and k is sum of the fixed costs f, h.

4) $\pi = (1-\alpha)\overline{Y}\Theta tc^{-\alpha/(1-\alpha)} - k$

In contrast to Grossman et al. (2004, 2006), total market demand is not the simple sum of market for each country ℓ, in addition, consumption may be in the North or South. Total world market is a function of the total market size, but this is restricted to an inverse-distance weighted market potential. The market potential for any country is a function of the market size, where a larger market will induce more entrants subject to the fixed costs of entry. The fixed costs of entry are assumed to not be a function of country size, as such the costs of entering a market or country for production are the same whether the country is large or small. Implicitly, there are trade barriers between countries and that markets are spatially separated. In spite of trade barriers, tariffs on trade between country A and B are lowered than the fixed costs of establishing production facilities in country B to serve country B's market. Since transportation costs increase with distance, a country relatively near to country B is a likely source of goods (produced out of country B). Market potential increases with size, as measured by GDP, and increases with proximity. The inverse-distance weighted market potential or GDP is the key to understanding a firm's decision to serve a third country's market by direct investment or exports from a foreign affiliate. These additional assumptions better define the plausible integration strategies to emphasize export platform FDI and are necessary to test for complex FDI.

The generalized form of n-1 countries increases the likelihood of greater horizontal FDI to South countries, in contrast to much of the MNE literature and studies.

(5) $\overline{Y} = Y^i + Y^r$

(6) $Y^R = \sum_{j=1}^{k} dw_{i,j} \left(Y^j \right)$

(7) $dw_{i,j} = \dfrac{\min dist}{d_{i,j}}$ for all $i \neq j$

Total market demand ($\overline{Y}$) is the sum of host country demand (Y^i) and surrounding market demand (Y^r) given by equation 5. Surrounding market demand or potential (Y^r) is the row sum for each country from j to k of the product of other country's market demand (vector of GDPs for all non-host countries) and the weighted inverse-distance between countries i,j ($dw_{i,j}$). Finally in equation 7, the weighted inverse-distance between countries i,j is the minimum distance between any country pairs in the dataset divided by the distance between the capital cities of countries i,j where a country's distance from itself is assumed to be zero.[14]

Pure vertical is preferred by very productive firms that pay a high fixed cost, but attain the lowest possible per-unit cost of serving each market since the goods are assembled in destination market. The low productivity firms will have lower volumes of output and thus the fixed costs of FDI is less profitable than exporting (Grossman et al. 2007, p 229). Thus, as productivity increases, firms are more likely to engage in FDI,

14 The distance matrix is a symmetric matrix which is essentially an index of a mileage table where diagonal values are equal to zero and unity is the values for the closest country pair. Note: this matrix includes all countries for which there is available GDP data and differs from the weight matrix (used to generate the eigenvalues) since the latter only includes the panel of countries for which there is FDI data available.

especially through the South.

4.1 Data Sources and Methods

The source for direct investment data is the U.S. Bureau of Economic Analysis (BEA). The direct investment position on a historical cost basis is used for foreign direct investment. While the data measure US direct investment abroad at its book value, this is the "standard valuation method for financial accounting and thus is used by MNC's when reporting direct investment data to BEA" (BEA, 2007).

International financial data such as gross domestic product (GDP) levels, GDP per capita, GDP growth rates, population, and capital stock data come from the World Bank's World Development Indicators (WDI) accessed between January and October 2007. Following Baltagi et al. (2007) and the OECD, I use the permanent inventory method of estimating the capital stocks (OECD, 2001, p 43). There was no benchmark available for all countries, so the data were calculated for the longest time horizon possible, in some cases beginning in 1960. The gross fixed capital formation flow data were depreciated at a rate of 7 percent per annum whose summation is the capital stock. The home to host country capital stock ratio $K_{d,i}$ ($K_{d,i} = (k_d / k_i)$) is used to determine capital stock endowments and relative abundances. Ratios are chosen to more closely model the Knowledge Capital Model instead of levels (Baltagi, et al., 2007; Blonigen, et al., 2007; Carr, et al., 2001; Carr, et al., 2003).

The distance matrix was generated based on the Haversine formula for distance between capitals and largest cities of 238 countries with the longitude and latitude coordinates from CEPII (Mayer and Zignago, 2002). The distances were first computed for the capitals and the largest cities, then dropping the 13 countries whose largest city is not the capital city.[15] Another 33 countries did not merge into the dataset created from the converted shapefile into Stata format, most of which were very small islands or not independent countries.[16]

Human capital data are drawn from the Barro-Lee dataset on educational attainment (Barro and Lee, 2000). To differentiate between skilled and unskilled workers the percent of the population 15 years and older that attained tertiary education is used for skilled labor (SK). Conversely, the percent of the population that is unskilled USK is $USK = 1 - SK$. Since the data series ends in 2000 and there is little year-by-year rank variation though the entire trend seems to be rising, a cross section is used for 1995 data.[17] The corruption data are the Corruption Perception Index from Transparency International. The values are between 0 (completely corrupt) and 10 (no corruption). The age dependency variable is the ratio of dependents to the working-age population and has values between 0 and 1. Since dependents, young and old, require economic transfers from the workers higher values of the ratio indicate a higher economic burden on the working-age population. Dependents include the young and old outside of the labor force, where higher values of the ratio could indicate long-term demand potential

15 The countries are: Australia, Bolivia, Brazil, Canada, Benin, Germany, Cote d'Ivoire, Kazakhstan, Nigeria, South Africa, Tanzania, Turkey, and United States. Myanmar changed its capital from Yangoon to Nay Pyi Taw in 2006 and is outside of the time period under study.
16 The 25 countries are Norfolk Island, Niue, Nauru, Palestine, Pitcairn, Palau, Saint Helena, St. Pierre and Miquelon, Tokelau, East Timor, Tuvalu, British Virgin Islands, Wallis and Futuna. The 8 countries not found in CEPII data are Antarctica, Iraq-Saudi Neutral Zone, Kerguelen, Liechtenstein, Monaco, Jan Mayen and Svalbard, and Isle of Man.
17 If a 1995 observation was not available, 1990 data were used.

and have a positive relationship with horizontal direct investment. The age dependency ratio should have a positive effect on direct investment if the dependents are a potential consumer base for horizontal-type strategies or potential workers for vertical-type strategies. Alternatively, higher ratios would negatively impact direct investment if they are an economic burden signaling future tax increases to pay for their benefits.

The (surrounding) market potential variable is the row summation of the product inverse-distance weight matrix and the vector of GDP values (Tiefelsdorf, 2000). For countries i,j and g_{ij} is the (the weight of functional attributes of x and y between i and j. First, the matrix ($w_y(d_{i,j})$) was weighted by dividing each observation by the shortest bilateral distance, see equation 8.[18]

$$(8)\ W_y\left(d_{i,j}\right) = \frac{36.9}{d_{i,j}} \quad \forall i \neq j$$

Where the Wy is a matrix of all $w_y(d_{i,j})$ values.

$$(9)\ W_y = \begin{bmatrix} 0 & w_y\left(d_{i,j}\right) & w_y\left(d_{i,k}\right) \\ w_y\left(d_{j,i}\right) & 0 & w_y\left(d_{j,k}\right) \\ w_y\left(d_{k,i}\right) & w_y\left(d_{k,j}\right) & 0 \end{bmatrix}$$

The matrix W_y is a balanced matrix since the distances are time invariant, although the matrix of GDP values is only for 1999-2005 due to the compositional changes of countries. To expand the number of countries used to determine the market potential and to maximize the inverse distance weighted matrix values for GDP for 6 countries were

18 The distance from Austria to Slovenia is 36.9 miles, but the shortest distance is between Democratic Republic of Congo and Republic of Congo (Brazzaville and Kinshasa) is 7 miles. The Austria-Slovenia distance was used to avoid rounding errors.

estimated using either averages of adjacent values or were imputed from the relevant 10 year average GDP growth rate—none of these countries were used for observations as independent variables.[19] The final matrix for surrounding market potential (1999-2005) included 173 countries see figure 1 below. Countries in the lowest quartile (in tan) are relatively far from the largest economies or close to small economies while those in the highest quartile (dark brown) are closest to large economies. It is important to note that the home country's economy (GDP) is excluded from the calculation. The US is included as a destination market for final consumption, thus the market potential for Canada is extremely high.

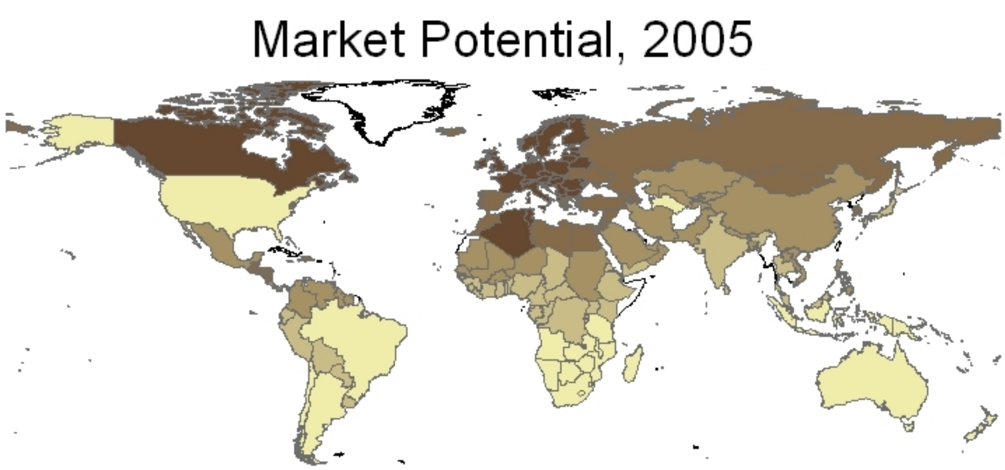

Figure 1. Surrounding Market Potential for 173 countries, 2005

19 Imputed GDP values for the following countries and years in parenthesis: Aruba (2004-2005), Bahamas (2003-2005), Brunei (2005), Cyprus (2005), Oman (2005).

The final weight matrix only included the countries for which there was data for all of the independent variables for all years (1999-2005) to generate a balanced panel—missing observations create severe computational difficulties for the spatial estimations. Two countries had missing direct investment abroad (DIA) data imputed using the average of adjacent values.[20] The 44 countries used for observations for the estimations include 21 OECD countries, see figure 2 below. Figure 2 illustrates the indirect market potential for US multinational's foreign affiliates.

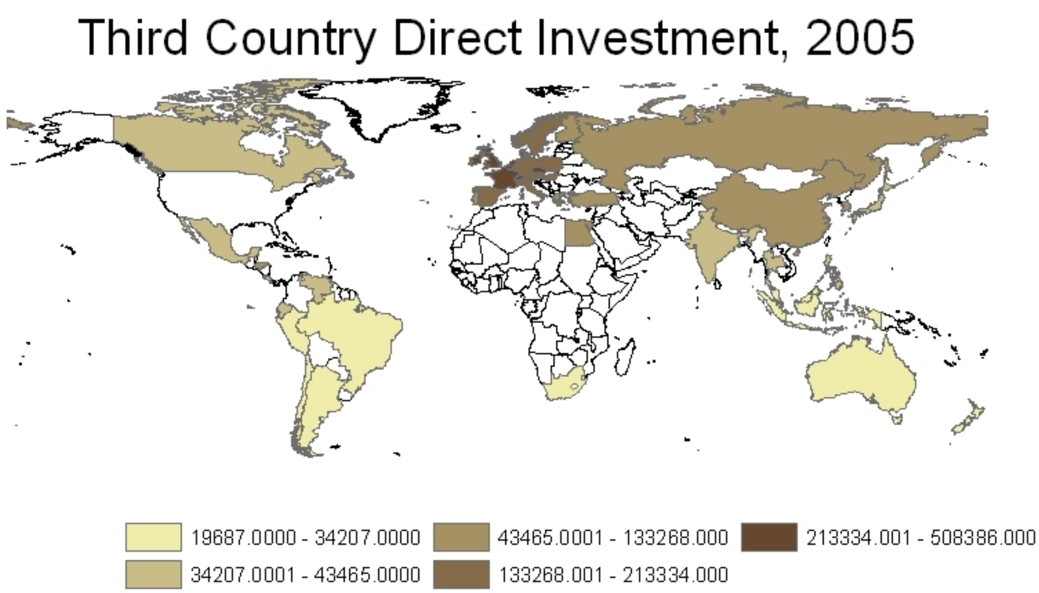

Figure 2. Distance Weighted Direct Investment Abroad, 2005
Starred countries are OECD members: Argentina, Australia*, Austria*, Belgium*, Brazil, Canada*, Chile, China, Costa Rica, Czech Republic, Denmark*, Ecuador, Egypt, Finland*, France*, Germany*, Greece*, Honduras, Hong Kong, Hungary, India, Indonesia, Ireland*, Italy*, Japan*, Republic of Korea*, Malaysia, Mexico, Netherlands*, New Zealand*, Norway*, Peru, Philippines, Poland, Portugal*, Russia, South Africa, Spain*, Sweden*, Switzerland*, Thailand, Turkey, United Kingdom*, Venezuela

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20 Missing data for Australia (2004) and Indonesia (2002-2004) were blocked due to confidentiality requirements of the BEA.

Countries in the lowest quintile (in tan) are relatively far from the U.S. or have relative small economies. The (third-country) weighted direct investment to Canada and Mexico are both in the fourth quintile, although both countries are close to the US. However, the absolute direct investment values are not adjusted for population or GDP, which are relatively low for Canada and Mexico, respectively. The highest quintile of countries, in dark brown, are primarily found in Europe that are relatively close to the other countries attracting large FDI inflows.

4.2 Estimation Models

A three step approach was taken to first estimate the relationship between direct investment as a function of distance (from the US) and host country variables using OLS, followed by a fixed effects estimation, and finally a spatial autoregression (spatial lag estimation). The OLS estimations add the weighted direct investment and market potential. All observations are in log form.

(10) DIA = $\alpha 0$ + $\alpha 1$ Host Variables + ε

(11) DIA = $\alpha 0$ + $\alpha 1$ Host Variables + $\alpha 2$ W*DIA + ε

(12) DIA = $\alpha 0$ + $\alpha 1$ Host Variables + $\alpha 2$ W*DIA + $\alpha 3$ Market Potential

+ $\alpha 4$ W*Host Variables + ε

Equations 10-12 are modified gravity models of direct investment. Host Variables include distance from the US, GDP, population, corruption, factor (capital stock, skilled labor, and unskilled labor) endowment ratios and the inverse-distance weighted host country variables (including GDP). All estimations, calculations, and figures were produced in Stata including the row standardized eigenvalue matrix. Estimation results are in tables 4 and 5 in section 5.

In standard notation the spatial autoregression is given by equation 13.

(13) $y = \rho W_y + x\beta + \varepsilon$

Where y is a vector of observations of the dependent variable, W is an *n* by *n* weight matrix (distance or contiguity), x is an *n* by *k* matrix of k exogenous variables, β is a *k* element vector of coefficients, ρ is the spatial autoregressive term whose values are between -1 and +1, and ε is an *n* element vector of error terms (Coughlin and Segev 2000, p 16-17). The strength of the correlation of the residuals is ρ (rho).

(14) $\varepsilon_i = \rho \sum_{j=1}^{n} w_{ij}\varepsilon_j + u_i$

> where ε_i is the residual or error term of a linear regression and w_{ij} is a measure of connection between regions *i* and *j*, ρ is a measure of the strength of the correlation of the residuals, and u_i is the remaining error term, after the correlation among residuals has been accounted for. Note if $\rho = 0$, the model reduces to the ordinary least squares model. (Rogerson 2006, p 246).

For the spatial error (autocorrelation) model the functional form is presented in equation 15 and the error term (ε) in equation 16.

(15) $y = X\beta + \varepsilon$

(16) $\varepsilon = \lambda W\varepsilon + \mu$

The spatial autocorrelation is found in the error term where λ is between -1 and +1 and indicates the effects of neighboring shocks on the dependent variable while μ is an *n* element vector of error terms (Coughlin and Segev, 2000, p 17). Results for the spatial lag and spatial error models are presented in Appendix 2.

The two estimation techniques to identical complex FDI and the MNE integration strategy differ considerably. The spatial lag model is employed by Blonigen et al. (2007) to assess the impact of agglomeration and substitution effects as well as estimates that are more comparable to the bulk of the FDI literature which considers the level of FDI activity. The interpretations of the coefficients of the spatial lagged variable and the surrounding market potential are mapped to uniquely identify four different MNE integration strategies; the results are summarized in table 2.

Table 2. Summary of Hypothesized Spatial Lag and Market Potential Coefficients for Various Forms of FDI

Explanatory Variable	Horizontal	Export-Platform	Vertical	Complex Vertical[21]
Spatial Lag	0	-	-	+
Market Potential	0	+	0	0

Horizontal MNEs operate with high trade costs and low fixed costs of establishing affiliates, a relationship known as the proximity-concentration trade-off. "The proximity-concentration hypothesis predicts that firms are more likely to expand production horizontally across borders the higher are transport costs and trade barriers and the lower

21 "Complex Vertical" is the same conceptually to Blonigen et al.'s (2007) name of "Vertical Specialization (with Agglomeration)".

are investment barriers and the size of scale economies at the plant level relative to the corporate level" (Brainard, 1997, p 520). There should be no spatial relationship between markets if it is only horizontal FDI: firms make independent decisions about which markets to enter through exports or affiliate sales as explained by the proximity-concentration tradeoff which governs the horizontal decision (Blonigen, et al., 2007, p 1307). Table 1 describes the export platform FDI when production is in countries d and i and exports (for final consumption) from i to j. This implies a negative spatial lag since it substitutes for FDI to other proximate markets. Secondly, the location of the export platform should provide lower cost access to third markets which implies a positive correlation for FDI and market potential variables (market size of proximate markets).

Vertical FDI is the result of a firm shifting each of the stages of production to the lowest cost producer. Vertical FDI is expected to have a negative spatial lag since FDI into one country is a substitute for FDI into nearby countries. Since the destination market is d or i, not j, the market size of j (all third countries) will not have any impact of the vertical MNE.

Complex vertical FDI involves production in i and j for consumption in d. Due to several firms locating near to each other, spillover benefits produce agglomeration economies where the FDI into proximate countries in complementary, thus there is a positive spatial lag. Complex vertical FDI is most likely in a zero-transportation cost environment, and as such, the size of proximate markets has no motivational power for these firms.

The other MNE strategy identification procedure is based on Markusen's Knowledge Capital model and is an extension of Carr et al. (2001) to estimate complex FDI (Markusen, 2002). As such, the model is based on relative factor abundances, unlike Blonigen et al. (2007) that use absolute levels.

The coefficients of third countries' relative endowments are used to identify different MNE organizational forms. Note that the coefficients in table 3, are for country *j*, not country *i*. The values for country *i* are invariant to MNE organizational structure, that is, a relative abundance of capital stock or skilled human capital will always attract FDI, while a relative abundance of unskilled labor will always reduce it (Borensztein, et al., 1998). Capital stock is negative for complex vertical due to country j's relative production cost disadvantage and is negative for horizontal due to a relative demand reduction. The other two are positive due to relative production cost advantage "of i resulting from an increase in k_j exerts a positive impact on bilateral FDI" (Baltagi, et al., 2007, p 265).

An increase in skilled labor between the home country (d) and the third country (j) or h_j ($h_j=h_d/h_j$) lower production and set-up costs where vertical MNE types are dominated by a crowding out effect, but horizontal types are not. "the reason that the former's [vertical type] whole production takes place abroad and is discouraged by the domestic savings effect. In contrast, h-type MNEs also produce at home so that they take advantage of both lower fixed costs and the production cost savings effect" (ibid, p 265).

Table 3. Expected Coefficients and Firm Strategy for Relative Factor Abundances of Third Countries

Explanatory Variable	Horizontal	Export-Platform	Vertical	Complex Vertical
Capital Stock (k_j)	-	+	+	-
Skilled Labor (h_j)	+	+	-	-
Unskilled Labor (l_j)	+	-	+	-

Note: coefficients for country *j*, not country *i*.

An increase in lj (lj=Ld/Lj, from a reduction in Lj) increases production costs in j relative to i, but lowers total income of j. Vertical and horizontal MNEs are negatively affected, export-platform and complex vertical is positive. “the reason is the presence of trade costs. Export-platform firms’ trade is less affected by the income reduction in country j than horizontal firms’ trade, since the latter export from the larger country” (ibid). Vertical type MNEs face greater exposure to trade costs, thus to identify complex vertical firms, it is important to not only use the bilateral distance (*d* to *i*) but the distance to third market (*d* to *j*) and this motivates the distance matrix.

Equations 10-12 estimate the OLS and FE models where the host county variables are based on the KK model like Baltagi et al. but also includes the market potential and spatial autoregressive term of Blonigen et al. to simultaneously ground the model in rigorous theory and to compare the relative effectiveness between the two approaches. Equation 17 is an applied version of equation 13 for the spatial autoregression where capital Greek letters (in bold) represent matrices.

$$(17)\ \text{DIA} = \beta_0 + \beta_1 \text{ Distance} + \beta_2 \text{ GDP} + \beta_3 \text{ Population} + \beta_4 \text{ Capital Stock} + \beta_5 \text{ Skilled Labor} + \beta_6 \text{ Unskilled Labor} + \beta_7 \text{ Corruption} + \beta_8 \mathbf{P} + \rho\beta_9 \mathbf{\Theta} + \beta_{10} \mathbf{\Phi} + \beta_{11} \mathbf{\Psi} + \beta_{12} \mathbf{\Lambda} + \varepsilon$$

Where W represents the 44-country weight matrix and J is the 177 country distance weight matrix and the third country interaction terms (P, Θ, Φ, Ψ, and Λ) are P = J*GDP, Θ = W*DIA, Φ = W*Capital Stock, Ψ = W*Skilled Labor, and Λ = W*Unskilled Labor. Rho (ρ) is the strength of the spatial autoregression residuals. The advantage of this framework is that it allows the direct comparison of two different identification procedures while incorporating an more recent time period than previous studies have done as well as the role of institutional constraints on FDI.

5. Empirical Results

The estimations results for the OLS, fixed effects (FE), and spatial autoregressions (SAR) from equations 10, 11, 12, and 17 are presented in table 4.[22] All variables are in log-form. The distance from the US is expected to have a negative coefficient like other gravity models while GDP and population are expected to have positive and negative coefficients, respectively.

In the absence of any competition measures, the larger the economic size of an economy, the greater are the potential economic profits relative to the fixed costs of acquiring a foreign affiliate. The negative coefficient on population and the positive coefficient on GDP preclude the inclusion of a single measure for GDP per capita. The Corruption Perception Index is expected for produce positive coefficients since higher values indicate *less* corruption. The remaining variables are the three factor proportions variables for third countries and the final two are the (surrounding) market potential and

22 The Hausman test confirmed the fixed effects or within estimator is unbiased. Results for the random effects estimation are presented in Appendix 2.

the weighted FDI (autoregressive term). Each set of variables can be used to identify the prevalence of MNE integration strategies.

Table 4. Direct Investment, All Industries, 1999-2005

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) FE	(6) SAR
Distance	-0.36**	-0.20	0.53**	0.66**	0.00	0.65**
	(0.18)	(0.19)	(0.27)	(0.29)	(0.00)	(0.26)
GDP	1.63***	1.28***	1.71***	1.63***	1.62**	1.77***
	(0.22)	(0.24)	(0.26)	(0.27)	(0.75)	(0.29)
Population	-0.21*	-0.16	-0.11	-0.16	-3.82**	-0.16
	(0.11)	(0.11)	(0.11)	(0.11)	(1.60)	(0.11)
Capital Stock	0.64***	0.33	0.80***	0.65**	0.10	0.79***
	(0.21)	(0.22)	(0.26)	(0.27)	(0.24)	(0.28)
Skilled Labor	-0.03	-0.04	0.18	0.17	0.00	0.06
	(0.24)	(0.25)	(0.26)	(0.26)	(0.00)	(0.23)
Unskilled Labor	-0.62	-0.82	1.00	1.00	0.00	0.66
	(1.26)	(1.33)	(1.33)	(1.34)	(0.00)	(1.27)
Corruption	0.53**	0.62***	0.78***	0.76***	0.26	0.78***
	(0.22)	(0.22)	(0.23)	(0.23)	(0.25)	(0.23)
W*Capital Stock	-0.08	0.22	0.64**	0.68**	-0.33	1.13***
	(0.25)	(0.25)	(0.28)	(0.28)	(0.34)	(0.28)
W*Skilled Labor	1.86***	0.68	2.06**	1.80**	0.00	0.85
	(0.68)	(0.74)	(0.82)	(0.82)	(0.00)	(0.87)
W*Unskilled Labor	-2.11***	-2.04***	-4.42***	-4.28***	0.00	-3.32***
	(0.64)	(0.63)	(0.84)	(0.84)	(0.00)	(0.91)
W*Direct Investment		0.76***	0.18	0.15	0.93***	-0.12
		(0.23)	(0.26)	(0.27)	(0.22)	(0.24)
Market Potential			1.93***	2.16***	-1.00	1.97***
			(0.46)	(0.50)	(1.34)	(0.45)
Age Dependency				0.82**	0.31	0.54
				(0.41)	(0.93)	(0.44)
Constant	-6.04	-8.70*	-38.32***	-39.72***	6.52	-49.66***
	(4.78)	(4.83)	(8.70)	(8.85)	(9.58)	(8.61)
ρ (rho)						0.83
						(0.15)
Observations	308	308	308	308	308	308
R-squared / Wald χ^2	0.70	0.71	0.73	0.73	0.44	29.86
-Log Likelihood						366.49
Number of id					44	

All observations are in log form. Direct Investment Abroad on Historical Cost Basis (log) is the dependent variable. Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

The OLS results (columns 1-3) all have a relatively high overall fit and the expected coefficient signs for GDP, population, capital stock ratio, and corruption. Amazingly, the distance from the US is only negative in regressions 1 and 2 and is positive and statistically significant in regression 3 when weighted GDP (market potential) is introduced. While the negative coefficient for distance on trade in the gravity model has been repeatedly confirmed, the effect of distance on investment is more ambiguous. Markusen reminds us that, "the Theory [of Multinationals] does not offer much of a prediction about distance" (Markusen, 2002, p 249). An increase in distance raises the transportation costs for both investments and exports, rendering the theoretical prediction indefinite. Von Thünen's model paid heavy attention to agricultural production where the full cost of all inputs to produce a crop are not fully borne by the agent.[23] The positive coefficient for distance in (3) may reflect transportation costs more negatively affecting production for export than direct investment.

The market size has a clear and strong effect in drawing in direct investment from the US with coefficients (or elasticities) between 1.3 and 1.7 for a one percent increase in GDP, similar to the findings of Blonigen et al. (2007). Populous countries attract less direct investment perhaps as a result of the lower capital stock per worker available for production, holding capital stock constant.

Increases in capital stocks have positive effects on attracting direct investment as hypothesized in the KK model. The results for the skilled and unskilled labor ratios are small, inconsistent, and statistically insignificant. Meanwhile, (the lack of) corruption

23 Farmers might pay for transporting seeds from the city to their fields, but do not truck water and fertilizers from the city, these are "delivered" for a much lower cost.

has a clear and positive effect on FDI—an effect that gets stronger as the model is further specified. The inclusion of third country direct investment (W*DIA) in regression 2 drop the coefficients and power for Capital Stock and W*Skilled Labor, but the values seem to return when market potential is added in regression 3. Conversely, the values for the weighted direct investment observations drop in value and significance when market potential is added. Market potential (weighted GDP) enters in regression 3 as positive and significant. However, once market potential is included the coefficient on distance turns positive and is statistically significant. This modified gravity now shows that investment increases with distance between countries when third country market potential is accounted for. An estimation of bilateral direct investment is dominated by firms concerned with high transportation, communication, and monitoring costs, while in the complex direct investment environment firms have sufficient host country monitoring to encourage investment as distance increases. According to the hypotheses of the spatial lag summarized in table 2, the positive market potential is consistent with export platform FDI. The weighted endowment variables in regression 3 are consistent with export-platform FDI as summarized in table 3. Namely, there are positive coefficients for (third country) capital stock and the skilled labor ratio while a very clear, negative coefficient for the unskilled labor ratio. An increase of one percent in the ratio of unskilled labor (relative to the US) for third countries j reducing investment to country i by 4.4 percent. The addition of the age dependency ratio in regression 4, enters positively and significantly as hypothesized for the dominant effect of a horizontal MNE integration strategy.

Potential spatial bias of OLS estimation results necessitates additional estimations. First, the standard deviations of the residuals from regression (for 2005 only) were plotted in figure 3. Spatial correlation would lead to clusters of countries by standard deviation. There is spatial clustering of OLS residuals.

The results of the fixed effects estimation results in column 5 are rather inconsistent with the OLS estimations due to the inclusion of several variables that are time-invariant (distance and labor) and corruption is nearly time-invariant. As such, the identification of MNE form based on the endowments method cannot be used. However, the positive coefficient for third country (or weighted) direct investment and the weakly negative coefficient for market potential signal the prevalence of complex vertical FDI.

The final estimation techniques uses the spatial autoregression, results in column 6 of table 4. The value of rho is 0.83 indicating a high spatial correlation of residuals. The distance from the US of the host country *i* again is positive. Coefficients for the SAR model are all very similar to OLS regression 4, except for third country skilled labor (W*SK) and third country direct invest (W*DIA). The former dropped from 1.8 to 0.9 and the latter dropped from +0.15 to -0.11. The third country relative capital abundance increased from 0.7 to 1.1 from the OLS to the SAR procedure. According to the identification hypothesis in table 2 from Blonigen et al. (2007) the negative coefficient for weighted direct investment and the positive coefficient for market potential are consistent with export platform FDI. The coefficients of the weighted third country endowment variables are likewise consistent with export platform FDI. The estimation procedures of compatible with each other. I hasten to note that for each technique one variable was not statistically significant.

For the two identification strategies and the three different estimation methods, export platform is the most common multinational integration strategy, see table 5. That is, on average, US multinationals favor a complex integration strategy over the simple horizontal and vertical structures.

Table 5. Summary of MNE forms

Technique	OLS	FE	SAR
Spatial Lag	Export Platform	Complex Vertical	Export Platform
Endowments	Export Platform	None	Export Platform

While US multinational enterprises tend to utilize an export platform strategy, that is, locate based on the host country's market potential as well as third country market potential, there is a great deal of variance in the estimates. As such, the residuals from each estimation method are plotted in figures 3, 4, and 5.

More than half of the countries' residuals were outside of a single standard deviation using the OLS method. The map results in figures 3 correspond with the regression results in column 4 of table 4. That is, figure 3 is based on the OLS regression including third-country market potential and the age dependency ratio. There is some clustering of countries above the median estimate in Europe: Ireland, Great Britain, Netherlands, Germany, and Switzerland. There is another cluster in Southeast Asia including Thailand, Malaysia, Indonesia, Philippines, and Hong Kong. With two exceptions Honduras and Chile, all of the Americas are within a standard deviation of the median regression estimates. Countries more than one standard deviation below the median are scattered, but include China, India, Russia, France, and South Africa.

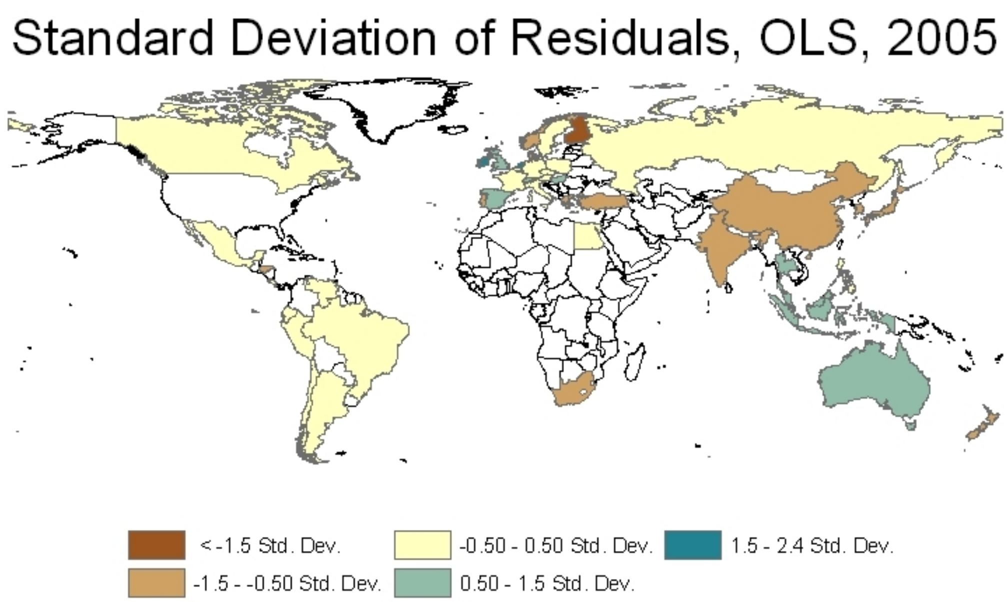

Figure 3. Standard Deviations of Residuals for OLS Regression, 2005

The residuals of the fixed effects results from column 5 of table 4 are mapped in figure 4. these results starkly contrast the OLS results. With the exception of Great Britain, all of Europe is at the median category or below it with clusters of Scandinavian and Central European countries below the median estimates. The model greatly over-predictions their direct investment from the US. South America, except Brazil is in the median category. Importantly, China, India, Indonesia, and Brazil are all two standard deviations above the median estimates—the model greatly under-predicts their direct investment from the US.

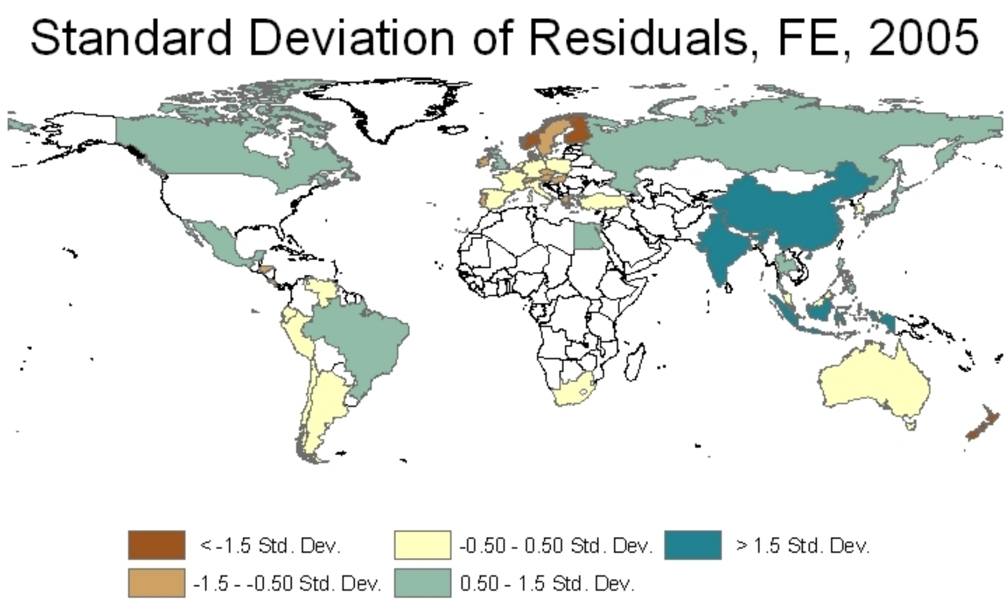

Figure 4. Standard Deviations of Residuals for Fixed Effects Regression, 2005

These developing countries with residuals well above the median estimates are all relatively unskilled labor abundant to the US, meaning that they have relatively greater competition and lower wages for unskilled labor services. However, these data were dropped under the fixed effects estimation because they were estimated as time-invariant in the panel data. Inclusion of the relative factor abundances would certainly strengthen the model and produce a less systematic spatial variation of residuals.

The spatial patterns of the residuals of the SAR model immediately reverse the patterns from the FE model. India, China, Russia, and Scandinavia all move into the median category of residuals. The SAR model captures the individual country variation of direct investment from the US. Thailand, the Philippines, and Indonesia move from being one and two standard deviations above the median to each of them one category below the median when relative factor abundances are included.

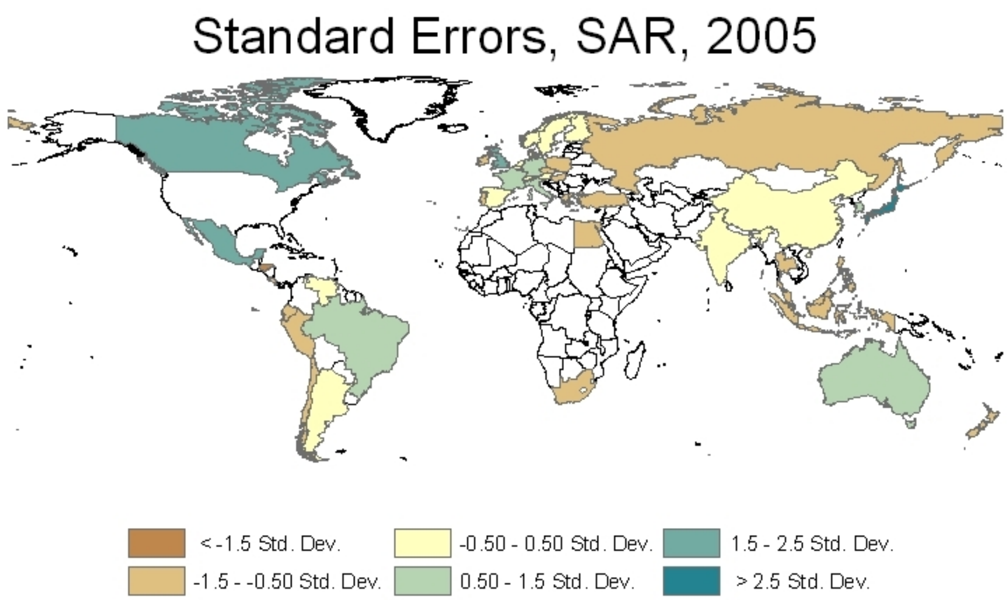

Figure 5. Standard Deviations of Standard Errors for SAR, 2005

However, the OLS method included the relative factor abundances and produced results like the fixed effects method. Although distance between the countries is included the model vastly under-predicts the US direct investment to Canada and to a lesser degree for Mexico and much of Western Europe. Canada and Mexico have fewer trade and investment barriers as a result of NAFTA and Western Europe garners most of the North-

North direct investment flows, in addition to the common language and long-term business relationships between firms in those countries. Inclusion of cultural and linguistic variables might lead to better estimates of US outward direct investment.

The spatial autoregression had the fewest residuals more than one standard deviation from the median estimate. Both the fixed effects and OLS methods produced residuals for more than half of the countries outside of one standard deviation. The SAR method, in contrast, had fewer than half of the residuals more than one standard deviation from the median estimate. By implication, the SAR method produced the most estimates in the median category. The SAR method centered the overall estimate to produce the fewest outliers compared to the OLS or FE methods. The SAR method best captures individual country variations to explain US outward direct investment.

6. Conclusion

The type of integration strategy of US MNEs is a function of the dominant motive for investing by the firm. Horizontal MNE are more likely to develop additional host-country linkages, while vertical MNEs maximize the comparative advantage of each country and may have a shorter investment time-horizon. Multinationals maximize the revenue subject to a multi-country, multi-period model producing a complex array of outcomes. Two theoretic and empirically different methods of identification of MNE integration strategy were compared using three different estimation procedures, OLS, FE, and SAR.

While OLS estimations can be biased due to spatially correlated errors, the coefficient results are generally consistent with those of the spatial autoregression. The results for the fixed effects estimation are inconsistent with the OLS estimations due to the inclusion of several variables that are time invariant. A full panel of endowment data, may not alleviate the discrepancies, yet the spatial lag approach to identifying complex FDI forms offers more potential. Strictly speaking, the spatial lag model requires a spatial autoregression, although the OLS and FE estimates and consistent with the SAR outcomes. In short, the FE technique is not conducive to the endowment approach, which is theoretically well-grounded, while the FE technique works reasonably well for the spatial lag approach. The SAR model produces spatially unbiased errors, albeit via a computationally laborious and inflexible method. The OLS technique requires more caution due to the known spatial correlation of residuals, yet the results have been consistent with the spatial autoregression model's results. The presence of spatial correlations and spatial dependency introduces spatially correlated error in the residuals of OLS regressions. The SAR produced the fewest outliers of residuals of any technique.

For both identification methods and for all three of the estimation procedures, complex MNE organizational types are supported, when one is clearly found. Complex vertical is identified once and export platform the other four times. It is clear that US MNEs, as a whole, act beyond the simple horizontal and vertical paradigm. By no means are all US multinationals operating as a single organizational type everywhere, but export platform FDI remains most likely to other developed countries and complex vertical to developing countries.

MNE organizational type is a function of country characteristics, yet spillover benefits from linkages and agglomerations are more likely the result of complex MNEs. As a result developing countries need to address policies which attract not just foreign direct investment, but MNEs that establish facilities for both production for local and regional consumption and export.

Chapter 3. Foreign Direct Investment and Trade: Effects on Income

> "What moves from country to country when a direct investment takes place is not primarily physical capital or production capacity, but rather intellectual capital, or techniques of production, unobserved and unmeasured. There may be movements of physical or financial capital accompanying the intellectual capital, but there need not be, and they are not the essence of the investment." (Lipsey, 2002, p 14)

The relationships between international trade and economic growth and foreign direct investment (FDI) require an empirical cross-examination to deduce the combined effects of trade and FDI on long-run economic growth. Foreign direct investment is investment in capital structures or a "lasting management interest" in an existing enterprise. "It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments" (WorldBank, 2006). From 1978 to 2004, world FDI inflows has increased 6.5 times while world trade has increased 1.7 times and most of this growth occurred in the 1990s (ibid). Most FDI is between developed economies, or North-North, however, developing countries are starting to close the gap.

Foreign direct investment is undertaken by the most profitable multinational corporations (MNEs) and may come from either the market access motive or the comparative advantage motive. FDI may have two opposite effects on domestic investment. First, multinational enterprises might crowd-out domestic firms due to lower costs and more advanced technology. Second, MNEs might create crowding-in effects by increasing productivity through the spillover of advanced technologies and through the development of backward and forward linkages (Borensztein, et al., 1998). Host countries benefit directly from the increased production capacity due to increases in output, employment, exports. Secondly, foreign firms may not be able "to internalise their advantages fully, so local firms benefit through spillovers" (Girma, et al., 2001, p. 120). Spillovers might come from competition effects, demonstration effects, or via labor training (Blomström and Kokko, 1998). Linkages might crowd-in investment through direct linkages or indirectly through arm's length transactions. Spillover benefits include: "greater efficiency due to increased competition, greater non-specific human capital investments due to labor migration, faster adoption of new technology, improved management practices, and increased financial mobility" (Globerman, 1979, p 43).

This paper addresses the empirical relationship between trade and foreign direct investment and more specifically whether trade and foreign direct investment are substitutes or complements. If firms undertake direct investment instead of exporting to the destination country, then FDI and trade are substitutes. Otherwise, complementarity of FDI and trade, crowding-in, may indicate formation of additional networks and international fragmented production methods. The results have a direct bearing on estimates of the effect of trade on income. Both trade and FDI are expected to generate more income, while FDI can also generate more trade. The inclusion of FDI may indicate a separate channel by which trade raises income. FDI is shown to have a positive impact on trade leading to a larger impact on income. The effects on trade are asymmetrically sensitive to its components, exports and imports. The effect of outward

FDI has clear and opposite effects on exports than on imports, which is not true for inward FDI. As a result, the aggregation of two variables which produce opposite outcomes, namely exports and imports, needs to be avoided.

The next section presents a simple OLS regression of trade on income that the uninitiated researcher might attempt. However, this approach is fraught with statistical and theoretical problems that are corrected via the instrumental variable regression technique. Section 3 summarizes some of the relevant research while section 4 discusses the empirical methods and data sources. The next section compares the asymmetric effect of outward FDI on export and imports. The following two sections (6 and 7) present each of the two stages of the regression results, respectively. Section 8 comments on the knowledge transfer problem with respect to foreign affiliate activity and provides additional avenues of research while section 9 concludes.

2. Problems with Simple OLS Regressions

The question of the effect of trade on income is not simply estimated using ordinary least squares (OLS) without statistical and theoretical problems. The results reported in table 6 address the effects of trade openness, population, area, and education on GDP per capita. Trade openness refers to the percentage of exports and imports of total GDP. Countries with higher values of trade openness rely more on international trade for economic growth than countries with low values of trade openness. The effects of inward FDI are included in column (3), where inward FDI is the amount of foreign-owned investment flows as a percent of total GDP.[24] Using a simple OLS technique on a panel of data for 188 countries, the coefficients for trade openness range from -0.39 to -0.80. Countries whose GDP is comprised of more exports and imports have lower incomes per capita—trade reduces income. There are two measures of human capital used, "Education1" and "Education2". Education1 is the log of the percent of the population that have completed secondary school, while Education2 is the log of the average number of year of secondary schooling in the population. Both human capital measures enter positively and significantly. The largest coefficient on trade openness occurs when inward FDI enters with a positive coefficient (column 3), while is slightly decreases when inward FDI is included with a human capital measure. Countries that garner more FDI are richer—FDI raises income. Additionally populous and small countries have lower incomes per capita where human capital raises income, although there are no theoretical predictions for such coefficients. The coefficients for inward FDI and human capital all produce the expected coefficients for their effects on income (GDP per capita) using the OLS estimation procedure, while trade openness reduces income.

Fortunately for the dismal science, the results are specious. Theoretically, it is difficult to accept large, aggregate, and persistent losses from international exchange. Econometrically, there is both the possibility of different intercepts, spatially correlated errors and endogeneity, where trade and income are both endogenous to each other. That is, both could be independent variables (RHS) when the other is the dependent variable.

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24 Inward FDI is gross, not net of outward FDI. Thus countries may have high values from both inward and outward FDI.

Table 6. Simple OLS Regressions of Trade on Income, 1980-2005

	(1)	(2)	(3)	(4)
Trade Openness	-0.55***	-0.39***	-0.80***	-0.59***
	(0.08)	(0.06)	(0.09)	(0.06)
Population	-0.10***	-0.11***	-0.10***	-0.10***
	(0.03)	(0.02)	(0.03)	(0.02)
Area	-0.06***	-0.07***	-0.06***	-0.08***
	(0.02)	(0.01)	(0.02)	(0.02)
Education1	1.67***		1.63***	
	(0.03)		(0.03)	
Education2		1.69***		1.66***
		(0.03)		(0.03)
Inward FDI			0.14***	0.11***
			(0.02)	(0.01)
Constant	4.58***	9.15***	4.92***	9.33***
	(0.27)	(0.20)	(0.28)	(0.21)
Observations	2,176	2,176	1,994	1,994
R-squared	0.51	0.70	0.52	0.70

Dependent variable is (log) GDP per capita
Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

For instance, rich consumers demand a wider variety of goods, both domestically produced and imported such that developed countries export and import more than developing countries. Conversely, gains from exchange lead to greater specialization and higher incomes. Fortunately, there is a remedy for endogeneity—the instrumental variable approach. The panel of data has repeated observations for each country over the 26 year period. Since the data may have internal correlations that are more apparent via grouping the observations by country or year, a fixed effects estimator is applied where the observations are grouped or fixed by country. Fixing observations by country implies that external shocks affect each country differently, regardless of the time period, as opposed to fixing by time which implies each country responds in the same way to a change for a given year.[25]

An instrumental variable regression, or 2-Stage Least Squares (2SLS), uses a third variable which has an effect on only one of the two variables. Specifically, to discern the effects of trade on income a variable is needed that affects trade, but has no relationship with income. Income might be spatially dependent for a sub-set of countries that have common geographic characteristics or favorable institutions. While developed countries tend to exhibit the properties of Tobler's first law of geography through high levels of direct commerce and proximity, it is the geographic advantages (water access, temperate climate) combined with the institutional advantages (the rule of law or low corruption) that lead to higher incomes. The spatial clustering of high income countries is an outcome of geographic and institutional advantages.

The gravity model posits a negative relationship between bilateral trade and distance between two countries and a positive relationship between bilateral trade and country size, see equation 18.[26]

(18) $\text{trade}_{ij} = \text{distance}_{ij} + \text{size}_j + \varepsilon$

Where i, j are countries home and foreign respectively

As distance increases between countries i and j, home and foreign, transaction costs increase, the number of substitutes expands, and cultural distance between countries increases as well—all of which reduce trade. Larger countries attract more trade and thus

25. Frankel and Romer (1999) fix by year, but I fix by country. As such, time invariant variables for each country, such as size are dropped from regressions.
[26] Country size may be in terms of population, land area, surface area, or output.

there is a positive relationship between trade and country size. There is an assumed high potential profit in economically large countries to sufficiently off-set fixed costs in a world of trade barriers or costly transportation. While distance between countries affects trade, it does not influence income. In spite of some spatial clustering of high income countries, the number of agents is sufficiently large for distance to retain the expected relationships given the spatial complexity of the world.[27] Thus, the bilateral distance between two countries can be used to create an instrumental variable to estimate the effect of trade on income.

3. Literature Review

This section reviews some of the relevant literature concerning multinationals, and relationships between FDI, trade, and income. The theories of organization that describe multinationals are important to describe the landscape in which their investment flows and stocks interact this trade and have repercussions on long-term income of the host country. The complex investment decisions of multinationals have implications for the home country, but as importantly for the host country and their development.

3.1 Theory of Multinationals

Multinational Enterprises are firms with production facilities in more than one country. Production refers to any phase of business including manufacturing, marketing, or

[27] If the number of countries (N) along a single line is sorted by income, then distance might affect income, however, if either 1) the countries are located on a plane or 2) if they are not sort by income along the line, distance will not have an effect on income.

headquarters services. Firm-specific advantages may be tangible (improved production process or innovation) or intangible (brand name, management structures, better employee knowledge).

The distinction between horizontal and vertical multinationals rests on the intended destination market for the product. Under the market access motive, the production of foreign affiliate of the MNE displaces exports to serve the host country's market parallel to domestic market. Horizontal FDI consists of investments that duplicate facilities and operation in several countries—final consumption takes places in the host country. Horizontal investment is most likely between similar countries. A vertical MNE produces aboard to take advantage of the comparative advantage of each step along the chain of production. The host country may not be the destination country for the final product. Differences in production costs between countries generate vertical direct investment. The distinction between horizontal and vertical MNEs provides a useful classification method, where vertical MNEs export goods for sale or further processing and horizontal MNEs displace trade (Markusen and Maskus, 2001). However, as Lipsey (2002) notes the distinction between vertical and horizontal MNEs is more useful theoretically, than practical (p 13).

Markusen develops a model of multinational behavior consistent with the industrial organization approach to trade known as the knowledge-capital model. He describes the knowledge-capital model as capturing, "the notion of horizontally integrated firms that undertake the same activity in multiple countries but excludes any motive for vertical specialization" Horizontal multinationals are the result (Markusen, 1984). In contrast, Helpman assumes no trade costs and production in capital-intensive and labor-intensive industries and thus models vertical multinationals (Helpman, 1984). Three key assumptions for Markusen's knowledge capital model are fragmentation, skilled-labor intensity, and jointness (Markusen, 2002, p129). Fragmentation asserts that "the location of knowledge-based assets may be fragmented from production" (ibid). Fragmentation is the technology transfer cost or the ease of supplying services to a foreign plant, which is the key concept to explain vertical multinationals (Markusen, 2002, p 129-130). Skilled-labor intensity directly affects the production of knowledge-based assets. Thirdly, "jointness" is public nature or spillover benefits of using knowledge-based assets as inputs into multiple production facilities. "Jointness is the key concept explaining motives for horizontal multinationals" (Markusen, 2002, p 129).

Several studies have used both the knowledge capital model and aggregate country data including Carr et al. in their estimates the knowledge-capital model (Carr, et al., 2001). Carr et al. (2001) find that trade and investment flows fit the model well. In addition, trade and investments are complements, but for similar countries they may be substitutes—consistent with horizontal investment (ibid 707).

The extensive use of foreign direct investment might lead to a truncated management structure where management services are relocated to the foreign country—encouraging a loss of skill-labor and might encourage a situation where there are "too many firms producing below an optimal size producing too diverse an array of output, which contributes to lower productivity in both foreign- and domestically owned firms" (Globerman, 1979, p 43).

Multinationals can be primarily viewed as organization which transfer knowledge-based goods and may be classified as horizontal or vertical. However, there are natural limits to the extent of vertical FDI.

3.2 FDI and Trade

The central issue is whether trade and investment are substitutes or complements. The proximity-concentration trade-off says that firms invest abroad when the gains from avoiding trade costs outweigh the costs of maintaining capacity in multiple markets (Helpman, et al., 2004, p 300). Direct investment is the response to the costs of distance for firms. Perhaps horizontal FDI and exports from the home country are substitutes for manufactured goods, but not necessarily for services, while vertical FDI increases exports from the home country. This conjecture is not empirically supported, however. A foreign affiliate's actions are too complex to classify into these categories when they perform multiple activities of the parent. "The foreign operation may omit some parent activities, because they are performed for the affiliate by the parent" (Lipsey, 2002, p 13).

Hanson et al. (2001) find that firms are motivated by both horizontal and vertical motives and that they may change over time. In the 1980s, firms used more horizontal FDI (based on North-North affiliate employment, while by 1999 non-OECD, especially China and Central and Eastern European countries attracted a growing share of affiliate employment (Konings, 2004).

"Empirically, however, most studies have found that the positive association between FDI and trade dominates. They tend to be complements, not substitutes."

(Frankel, 1997, p 129). Most studies find weak support for complementarity even controlling for industry (Lipsey and Weiss, 1981; Lipsey and Weiss, 1984). In spite of classification imprecision, the dearth of firm-level data, and changes over time, most studies support the complementarity of FDI and trade, including this one.

3.3 Trade and Income

Frankel and Romer use the instrumental variable (IV) approach to assess the effects of trade on income (Frankel and Romer, 1999). Frankel and Romer (1999) find that trade openness raises long-run economic "growth" by about 2.0 percent through the accumulation of physical and human capital and increasing output for given levels of capital (p 387).[28] Frankel and Rose (2002) follow up the Frankel and Romer (1999) article by considering the effect of a currency union or currency board on trade and income. These currency regimes minimize independent monetary policy although they may provide macroeconomic stability, while reducing the costs of international transactions. They find that common currencies promote trade and also openness while there is not support for trade diversion. They find that having a common currency or a currency board increases bilateral trade by about 3.9 times.

3.4. FDI and Income

FDI may have two opposite effects on domestic investment. First, multinationals might

28 Long-run economic "growth" is measured by per capital income, where income differences are the results growth differences over the long-run. "Income" is used throughout to indicate long-run economic growth.

crowd out domestic firms due to lower costs and more advanced technology. Second, multinationals might create crowding-in effects by increasing productivity through the spillover of advanced technologies. The author's findings support the crowding-in effect.

Borensztein et al (1998) find support for the crowding-in effect where FDI increases productivity, wages, output, and trade. However, the absorptive capacity of the level of domestic human capital limits the positive growth effects. Borensztein et al. (1998) find that FDI contributes more to the growth through technological progress than through total capital accumulation in the host economy, especially for countries with a sufficient level of human capital. Countries with very low levels of human capital (measured by male secondary schooling in 1980) have negative growth effects from FDI. The results show "strong complementary effects between FDI and human capital on the growth rate of income" (Borensztein, et al., 1998). That is to say, FDI can raise growth due to technological diffusion, which depends critically on the intellectual absorptive capacity of the host country.

4. Methods and Data

Following previous work which uses the gravity model to create instrumental variables to test the effect of trade on income, first the gravity equation is estimated, then the fitted values are used for the estimates on income (Dollar and Kraay, 2003; Frankel and Romer, 1999; Frankel and Rose, 2002).

The bilateral trade data are drawn from the Direction of Trade Statistics (DOTS) from the International Monetary Fund (IMF, 2007). These data cover all trade from 199 countries from 1980 to 2005. Income, population, area, inward and outward foreign direct investment, and human capital data come from the World Bank's World Development Indicators (WDI) and are collected for the time period and cover 210 countries (WorldBank, 2006). The third major source of data is CEPII from which distance measures were attained (Mayer and Zignago, 2002). The education panel data from Barro and Lee were converted from five-year intervals to a full panel using a linear extrapolation method for the intervening years (Barro and Lee, 2000). The Corruption Perceptions Index for 1995 to 2005 comes from Transparency International. In sum, the data cover 174 countries from 1980 to 2005. For the second stage of the regressions, a second dataset is used with a panel of countries, instead of bilateral trade. The sources are the same as noted above. Data descriptions are available in Appendix 3 and summary statistics are presented in Appendix 4. Data estimations, regressions, and transformations were developed using STATA and all figures were developed in ArcMap 9.2 (STATA Corp. version 9.2 SE, ESRI ArcMap 9.2).

Distance measures between countries are usually point-to-point. That is, distance between two countries is measured between largest cities, capitals, geographic centers, or economic centers. Each of these measures correlates highly with each other and is statistically robust in gravity models. The Head and Mayer weighted distance with the constant elasticity of substitution uses a simple weighted arithmetic average over all region-to-region distances inside a country and regional output to develop an economically-weighted distance measure. It correlates highly with other measures and was employed because it is more theoretically satisfying for modeling economic activity for space (Head and Mayer, 2002, p 12-13).

The inclusion for FDI to the second stage of the regression, fitted trade on income, could produce multicollinearity if trade and FDI both have positive effects on income and positive interactions. Hence, inward FDI was included in the gravity equation to explain trade. The resulting fitted trade instruments have accounted for the positive effect of inward FDI. Frankel and Romer (1999) omit additional variables because "...there is no strong reason to expect additional independent determinants of income to be correlated with our instrument" (p 386). Secondly, if they were included "the estimates of trade's impact on income would leave out any effects operating through its impact on these variables" (Ibid). The error term includes all unobserved or excluded variables. That is to say, when FDI is unobserved or excluded from the regression, the effect of FDI on income is not controlled for and is in the error term along with other unobserved variables. However, including FDI into the regression explicitly controls for its influence on trade and, in turn, on income—the increasing prominence of FDI in generating income necessitates this clarification.

Dollar and Kraay (2003) use the instrumental variable approach to examine the effects of institutions and trade on growth. They find that institutional measures, including rule of law, produce "overwhelming problems of multicollinearity in the second-stage regressions" (p 135). They conclude that institutions play a relatively larger role in the long-run compared to trade in the short-run. The Corruption Perception Index (CPI) from Transparency International was included in the second-stage regressions, but suffered form the same problems as detailed by Dollar and Kraay (2003). Estimates are included in Appendix 7.

5. Choice of Inward or Outward FDI and Asymmetries

The difference between inward and outward direct investment is analogous to the difference between exports and imports. Studies from the home country's perspective use inward direct investment and studies from the host country's perspective use outward direct investment. It is important to note that data are generally not available at the firm-level, or between any two countries for even the industry level. Studies using inward direct investment measure the effects of employment, productivity, wages, and prices for evidence of spillover benefits to the host country. Outward FDI is principally useful for looking the domestic effects of outsourcing on (un)employment, wages, and productivity. While inward and outward FDI differ in scope, their relationships to trade openness differ as well. Not only do inward and outward direct investment, as share of GDP, have opposite effects on trade openness, they have asymmetric effects on the components of trade: exports and imports. The choice of inward or outward FDI to assess the effects on trade depends on the scope of analysis, but it limited by the measurement of trade openness.

5.1 Inward FDI

Globerman investigates the productivity differences of manufacturing firms in Canada and finds that productivity differences are positively correlated with capital-intensity, labor-quality, average hours worked, and the amount of foreign ownership in the industry

(Globerman, 1979). In a later study of inward FDI in Canada, Globerman, Ries, and Vertinski (1994) find that foreign affiliates have higher value-added per worker and pay higher wages, but the effect vanishes once controlling for capital intensity and size.

Howenstine and Zeile (1994) find that foreign affiliates in the US tend to be larger than US firms in the same industry, though foreign firms tend to be concentrated in industries with larger-than-average plant sizes. Furthermore, foreign-owned firms tend to have higher productivity, higher capital intensity, and pay higher wages than similar US firms. Again, foreign firms tend to be concentrate in industries which have higher productivity, more capital intensive, and pay higher wages than the average industry does (Howenstine and Zeile, 1994, p 34).

5.2 Outward FDI

Girma et al. investigate productivity and wage gaps of foreign and domestic firms in the UK and then examine if there are any spillovers (Girma, et al., 2001) "In general, foreign firms pay around 6% and produce 11% more than their (four digit) industry average."(ibid, p 122). Productivity and wage growth rates are also higher for foreign affiliates.

Figlio and Blonigen (2000) find that foreign investment raises local wages much more than from domestic investment, although it lowers some local government spending and redistributes monies away from public schools.

MNEs have both higher labor costs and higher labor productivity than domestic-only firms. Konings (2004) finds that competition from low-wage countries in Central and Eastern Europe does not constitute a threat to parent employment elsewhere in Europe, especially when transportation costs are minimal (p 102).

In Europe, in particular France, the domestic impact on unemployment has been a concern. In general, there have not been negative employment effects. Lipsey (1999) asks whether there has been a net job loss due to US outsourcing. He finds, using BEA benchmark data, that there has not been a net job loss, however US firms are shifting labor-intensive production overseas, while foreign firms are shifting capital-intensive production to the US. "There has been no shift of employment in the aggregate from the domestic U.S. economy to the foreign operations of U.S. firms" (ibid, p 8). US manufactures have allocated more of their worldwide output to foreign operations (ibid, p 9). However foreign affiliates in the U.S. also allocated more production to the international market. "Thus, both the U.S. and foreign manufacturing firms were increasing their degree of internationalization; each group was producing more in the other's home market"(ibid, p 10).

Yeaple (2003) tests the effects of skill endowments on US outward FDI where he shows US outward FDI follows a pattern consistent with comparative advantage and secondly that trade friction between countries, plant- and firm-level scale economies, and countries' relative market sizes influence the structure of US outward FDI.

Outward FDI production via foreign affiliates rather than domestically should discourage exports and encourage imports from an agglomeration effect. Bilateral FDI data at the firm-level are optimal for an empirical analysis, yet aggregate direct investment data (by country) and bilateral trade data are available.

5.3 Empirical Asymmetric Effects of Outward and Inward FDI

To estimate the asymmetric effects of outward and inward FDI on trade, trade is decomposed into exports and imports. If there is a divergence between the effects of FDI imports, exports, and their summation (trade openness), then the usefulness of trade openness is jeopardized. A modified gravity model is used to assess the impacts of inward and then outward FDI on trade, exports, and imports is employed.

Equations 19-21 are used to empirically estimate the effects of outward direct investment on the exports and imports as well as their summation.

Outward FDI (OFDI) equations where i and j are home and foreign countries.

(19) $Trade_{ij} = Distance_{ij} + Pop_i + Area_i + Pop_j + Area_j + Landlocked + OFDI_i + \varepsilon$

(20) $Imports_{ij} = Distance_{ij} + Pop_i + Area_i + Pop_j + Area_j + Landlocked + OFDI_i + \varepsilon$

(21) $Exports_{ij} = Distance_{ij} + Pop_i + Area_i + Pop_j + Area_j + Landlocked + OFDI_i + \varepsilon$

A bilateral trade dataset in a gravity model shows that outward FDI as a percentage of GDP has a weak, but positive effect on trade (sum of exports and imports) as a percentage of GDP using a fixed effects estimator, column (1) table 7. However, decomposing trade into exports and imports, as a percentage of GDP, tells a different story, see columns (2) and (3).

The only substantial difference between the coefficients in columns (1-3) is for outward FDI. A one percent increase in outward FDI (for all countries and to all countries) decreases the share of imports as a share of GDP by 0.09 percent, while it increases exports by 0.05 percent. The coefficients have significant and opposite signs that when exports and imports are summed to produce the variable for trade, the resulting coefficient is especially small.

Table 7. Asymmetric Effects of Outward FDI on Exports and Imports, 1980-2005

	(1) Imports + Exports	(2) Imports	(3) Exports
$Distance_{ij}$	-1.50***	-1.44***	-1.47***
	(0.01)	(0.01)	(0.01)
Pop_i	-1.14***	1.07***	2.06***
	(0.07)	(0.08)	(0.07)
$Area_i$	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
Pop_j	1.10***	1.14***	1.02***
	(0.01)	(0.01)	(0.01)
$Area_j$	-0.29***	-0.30***	-0.27***
	(0.00)	(0.01)	(0.00)
Landlocked	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
Outward FDI	0.09	-0.07	0.09
	(0.07)	(0.10)	(0.08)
Constant	8.72***	-14.44***	-22.92***
	(0.68)	(0.81)	(0.72)
Observations	109,507	98,926	103,207
Number of Countries	95	95	92
R-squared	0.43	0.36	0.40

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependant variable in column 1 is nominal Trade (Exports+Imports)/nominal GDP, in log form.
Dependent variable in columns 2 and 3 are imports divided by GDP and exports divided by GDP both in log form, respectively. Populations, areas, and FDI are all in log form.

The empirical results from equations 22-24 to estimate the effects of inward foreign direct investment on trade and its compenents are presented in table 8. Concerning inward direct investment, the coefficient estimates for all of the variables are have the same sign and approximate value.

Inward FDI (IFDI) equations where i and j are home and foreign countries.

(22) $Trade_{ij} = Distance_{ij} + Pop_i + Area_i + Pop_j + Area_j + Landlocked + IFDI_i + \varepsilon$

(23) $Imports_{ij} = Distance_{ij} + Pop_i + Area_i + Pop_j + Area_j + Landlocked + IFDI_i + \varepsilon$

(24) $Exports_{ij} = Distance_{ij} + Pop_i + Area_i + Pop_j + Area_j + Landlocked + IFDI_i + \varepsilon$

Table 8. Symmetric Effects of Inward FDI on Exports and Imports, 1980-2005

	(1) Imports + Exports	(2) Imports	(3) Exports
$Distance_{ij}$	-1.34***	-1.23***	-1.32***
	(0.01)	(0.01)	(0.01)
Pop_i	-0.49***	1.11***	1.15***
	(0.05)	(0.05)	(0.05)
$Area_i$	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
Pop_j	1.13***	1.14***	1.06***
	(0.01)	(0.01)	(0.01)
$Area_j$	-0.33***	-0.33***	-0.30***
	(0.00)	(0.00)	(0.00)
Landlocked	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
Inward FDI	-0.03	-0.02	-0.05
	(0.05)	(0.06)	(0.06)
Constant	1.30***	-15.77***	-15.27***
	(0.44)	(0.50)	(0.49)
Observations	160,377	143,952	140,520
Number of Countries	150	145	148
R-squared	0.37	0.31	0.35

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependant variable in column 1 is nominal Trade (Exports+Imports)/nominal GDP, in log form. Dependent variable in columns 2 and 3 are imports divided by GDP and exports divided by GDP both in log form, respectively. Populations, areas, and FDI are all in log form.

Inward direct investment has a negative effect on both imports and exports. Thus, the asymmetric effects of imports and exports is only present for outward FDI and not for inward FDI. Thus, trade openness as measured by the sum of exports and imports as a share of GDP is distored when it's a function of outward FDI

6. Stage 1 Results: The Gravity Model

The gravity equation 25 is employed to test the effect of geographic variables on bilateral trade (trade as a share of GDP). Equation 26 includes inward foreign direct investment (IFDI). Distance and landlocked should have negative coefficients since land transportation is more costly than ocean transportation. If goods flow between similar countries, then population and area will have coefficients near zero. However, if trade flows from smaller countries, in terms of population and size, to larger countries, then home country size (Pop_i, $Area_i$) will have negative coefficients while foreign country size (Pop_j, $Area_j$) will have positive coefficients. Results are shown in table 9.

(25) $Trade_{ij} = Distance_{ij} + Pop_i + Area_i + Pop_j + Area_j + Landlocked + \varepsilon$

Where i, j are countries home and foreign respectively.

(26) $Trade_{ij} = Distance_{ij} + Pop_i + Area_i + Pop_j + Area_j + Landlocked + IFDI_i + \varepsilon$

Where i, j are countries home and foreign respectively.

In contrast to Frankel and Romer (1999), contiguity and its interactions with population, area, and landlocked are all omitted. Additional regression estimates that include population controls are reported in Appendix 6, though the estimates differ little.

Table 9. Stage 1. Gravity Model Without and With Population Controls, 1980-2005, Fixed Effects

	(1)	(2)	(3)
$Distance_{ij}$	-1.36***	-1.34***	-1.37***
	(0.01)	(0.01)	(0.01)
Pop_i	-0.68***	-0.48***	-0.57***
	(0.04)	(0.05)	(0.05)
Pop_j	1.15***	1.14***	1.15***
	(0.00)	(0.01)	(0.01)
$Area_j$	-0.36***	-0.34***	-0.34***
	(0.00)	(0.00)	(0.00)
Inward FDI		-0.03	
		(0.05)	
Lagged FDI			-0.06
			(0.06)
Constant	3.23***	1.31***	2.30***
	(0.40)	(0.44)	(0.43)
Observations	186,534	159,625	171,557
Number of Countries	165	150	151
R-squared	0.36	0.37	0.37

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependant variable is nominal Trade (Exports+Imports)/nominal GDP, in log form. Populations, areas, and FDI are all in form log.

Column (2) includes inward FDI for the current period and column (3) includes inward FDI lagged by 5 years. Comparing the results with and without the population controls, there are approximately 5,000 observations with countries that have less than 100,000 inhabitants trading. While there are sufficient degrees of freedom to permit population controls and many other variables, it does not change the coefficient estimates significantly and even weakens the overall power of the regression. Furthermore, trade with small countries should operate under all of the same assumptions subject to distance and size as larger countries. They do not bias the result—they help form the result. There is little variation in coefficient estimates with and without population controls. Small countries should not be considered outliers in the larger gravity model. For all specifications distance and landlocked enter significantly and negatively, as hypothesized. Foreign country area and home country area both enter with negative coefficients. Increasing the area of either the home or foreign country reduces trade, though more so for country j. Foreign country population enters positively and significantly. More populous destination countries trade more. Finally, inward FDI enters positively and significantly, as hypothesized. Countries absorbing more FDI also trade more. Column (3) is used to generate instrumental variables to estimate the effects on income.

7. Stage 2 Results: Trade on Income

The second stage of the IV approach uses the fitted values of the dependent variable in stage 1. Results from equation 27 are presented in table 10 below. With IV instruments and FDI in stage 1, the effects of trade on income increase to 5.3. Following Barro and Lee (2000) and Borensztein et al. (1998) the average number of years of secondary schooling of males is used to proxy for human capital.

The IV approach in columns (2 and 3) both indicate that trade openness, population, area, and human capital all have positive effects on income, as expected, but contrary to the simple OLS approach. Frankel and Romer's (1999) coefficient for trade openness, using a 1985 cross-section of data and slightly different gravity equation, was lower at 2.0, versus 3.3 (p 387). More importantly, trade openness has a larger positive impact on income accounting for the effect of inward FDI with a coefficient of 4.9, column (3). Because of the positive effects of FDI on trade, trade is shown to have larger effects on income than previously estimated.

(27) Income = Trade Openness + Population + Area + Education + ε

Table 10. OLS and IV for Trade on Income, 1980-2005

	(1) OLS	(2) IV	(3) IV-FDI
Trade Openness	-0.55	3.29***	4.85***
	(0.08)***	(0.46)	(0.79)
Pop_i	-0.10	0.22***	0.35***
	(0.03)***	(0.06)	(0.08)
$Area_i$	-0.06	0.23***	0.35***
	(0.02)***	(0.05)	(0.09)
Male Schooling	1.67	1.43***	1.33***
	(0.03)***	(0.05)	(0.08)
Constant	4.58	-4.07***	-7.60***
	(0.27)***	(1.11)	(1.92)
Observations	2,176	2,176	2,176
R-squared	0.51		
F-stat		294.61	182.83

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependant variable is log of (nominal) GDP per capita.

The standard deviations of the residuals from the OLS estimate (column 1) are mapped in figure 6. Countries in white are missing data and countries in yellow have residuals within 0.5 standard deviations on the median estimate. The model is relatively efficient at estimating the effect of trade on income for countries in yellow. Countries in the progressively darker shades of brown have residuals below the median estimate—the model over-estimates the benefits of trade for these countries. In contrast, the model under-estimates the benefits of trade on income for countries in shades of green. In the Americas, only Guyana and Nicaragua have residuals one standard deviation below the median estimate, while all other countries have estimates in the median category or above it. The residuals for Canada are approximately two standard deviations above the median for the positive effects of trade on income. Values above the median estimate are clustered in Western Europe. South Asia and Southeast Asia, except Thailand and Malaysia, are all below the median category. Surprisingly, some countries scattered across Africa have positive residuals, including Nigeria and Botswana, while most of the rest of the continent has residuals below the median.

The spatial clustering of residuals above the median estimate in North and South America and Western Europe as well as the clustered below the median in South and southeastern Asia and some of Africa indicate the presence of spatial dependence of the regression results. Controlling for country-specific and time invariant fixed effects might improve the results in the first stage of an instrumental variable approach to eliminate the endogeneity of trade and income. Secondly, accounting for an additional channel of knowledge transfer, just as multinational foreign affiliate activities, might lead to more spatial dispersed residuals.

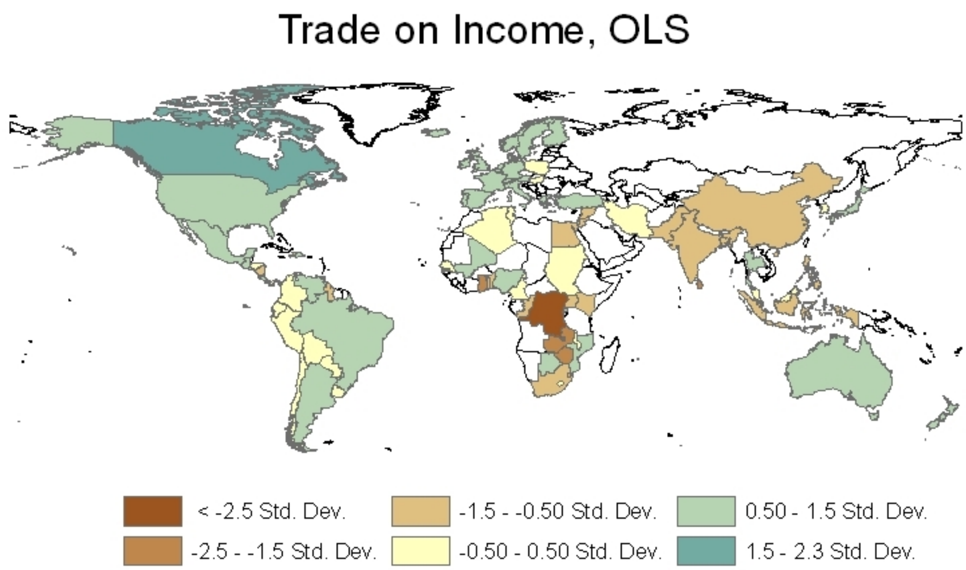

Figure 6. Standard Deviations of Residuals for OLS Regression

The IV approach reduces the number of countries with residuals above the median, but does not improve the spatial clustering, see figure 7. The positive clusters in North and South America and Western Europe are little better than in the OLS method, yet the negative residual clusters in Africa and South and Southeast Asia are stronger.

The spatial clustering of residuals for the effect of trade on income after accounting for the effect of FDI using the IV method is slightly moderated. The number of countries with residuals above the median estimate is the same as using the IV method without FDI, yet there are fewer countries with residuals below the median in figure 8. After including the long-term effects of FDI on trade to estimate the impact on income, more countries' residuals are in the median category. The negative residual cluster in Africa is present, though a little weaker and the South and Southeast Asia cluster is unchanged.

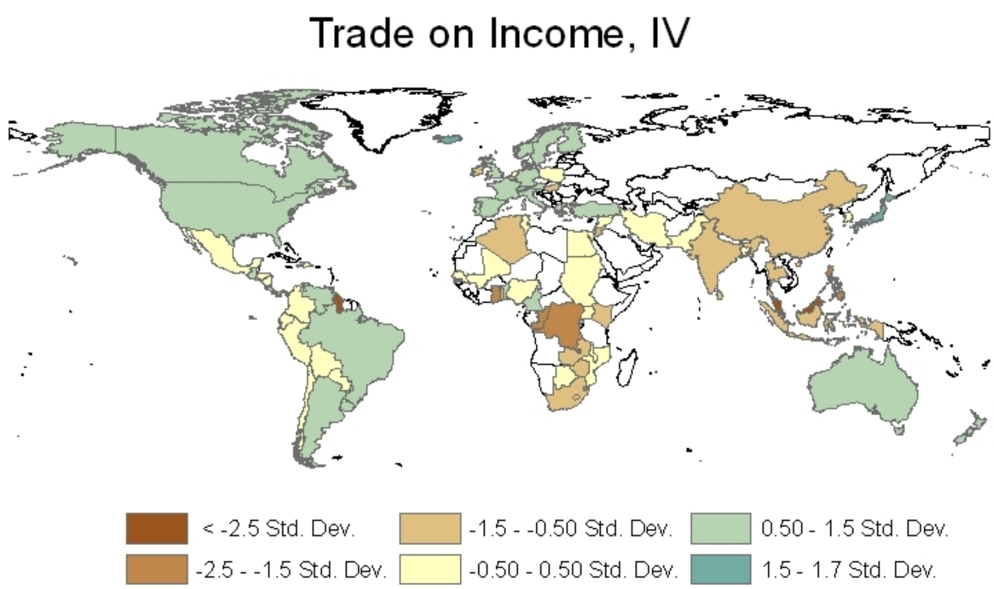

Figure 7. Standard Deviations of Residuals for IV

The complementarity of FDI and trade, especially in the long-run can lead to both FDI and trade to interact and to positively affect income. The inclusion of FDI in the 2-Stage Least Squares estimation improves the overall estimates and produces slightly less spatial dependence of residuals, see figure 8.

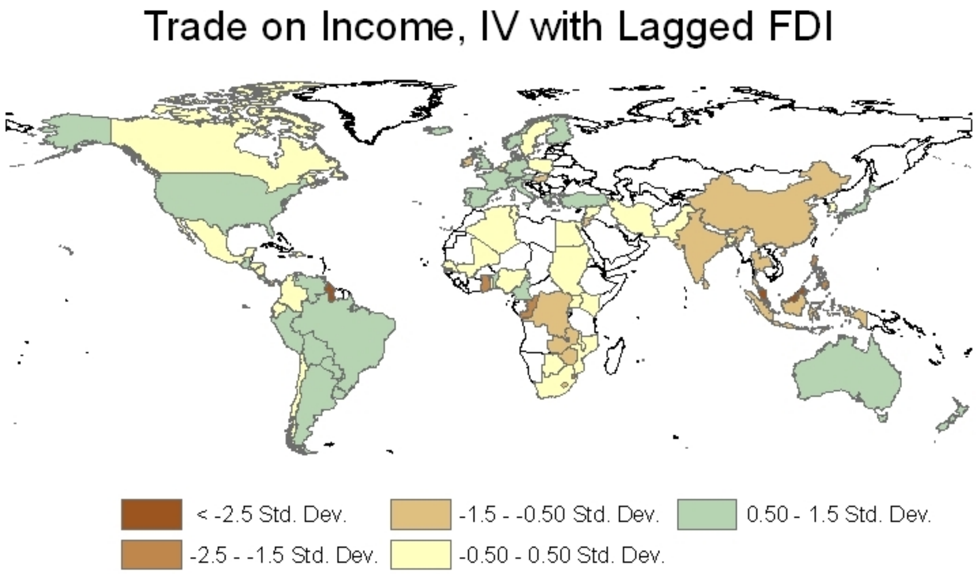

Figure 8. Standard Deviations of Residuals for IV with 5-year Lagged FDI

Due to the complementarity between trade and direct investment, estimates for the effects of trade on income are improved by using lagged foreign direct investment. Beside improving the effects of the determinates of income, there is slightly less spatial correlation of the residuals. The inclusion of FDI to the trade and income relationship has a positive effect on income and reduces the spatial variation of the model.

8. Knowledge Problem

There remains a knowledge transfer problem. Much of the benefits of FDI and trade are due to the generation of knowledge spillovers. Knowledge spillovers may be contrary to the plans of the foreign affiliate. Demonstration effects, for instance, require observation, interpretation, and implementation by domestic firms. Kathuria finds that indirect gains or spillovers are not automatic but depend on the extent to which local firms invest in learning or R&D to de-codify the spilled knowledge (Kathuria, 2000). Without sufficient human capital and institutional structures spilled knowledge may not be absorbed in the host country. However, the availability of firm-specific knowledge increases as the number of foreign firms increases. As a result, sectors, or even countries with higher proportions of foreign firms are more likely to raise the productivity in that sector or country as demonstration of the composition effect (Girma, et al., 2001, p 125).

Concerning the productivity gap, there are two opposite hypotheses. The first, spillovers are negatively related to the complexity of the MNE technology and the technology gap (Lapan and Bardhan, 1973). Several studies find that spillovers are most captured in industries where the gap is small. Conversely, a larger technology gap spawns more spillovers (Findlay, 1978).

Tacit knowledge to the firm may not necessarily be transferred to another firm, even one attempting to mimic the first (von Hayek, 1945). Each firm’s production process requires tacit and explicit knowledge, where it is not possible to easily transfer and incorporate tacit knowledge. Host country firms have incomplete knowledge relevant to copying the foreign affiliate even if there are clear demonstration effects.

9. Conclusion

Simple OLS estimates of the effects of trade on income suffer from endogeneity and produces results that are contrary to theory. The single stage estimation of trade on income, generate negative coefficients for trade openness—trade reduces income. Outward FDI modeled on disaggregated trade, exports and imports, produces opposite coefficient results, which should reinforce precautions to mis-specifying the model. These problems are corrected by using the instrumental variable approach.

Firms engage in direct investment due to the market access and comparative advantage motives, as well as combinations therein. If direct investment and trade are substitutes, the primary effect is a zero-sum gain, leaving only secondary effects, such as spillovers to generate any net gains to the host country. Through examining the interactions between FDI, trade, and income, positive inter-relationships are empirically supported to bolster the hypothesis that trade and direct investment are complements. As a result of this complementarity, host economies have a primary net gain from attracting both imports and direct invest as well as secondary gains from spillover effects, especially from the formation of linkages. Coupled with the empirical support for FDI increasing income and trade increasing income, estimates of the effect of trade on income without accounting for FDI will lead to an overestimate of the effect of trade.

Chapter 4. Geography and Trade: Effects on Income in a Fragmented World

1. Introduction

The innocuous-sounding term “geographic variables” provides greater theoretical and statistical significance than many economists have anticipated. The gravity model has evolved from a statistical curiosity to a theoretically robust relationship that has been derived from several different trade models (Feenstra, et al., 2001). While many economists have dabbled with it, relatively few have delved further into other geographic specifications which can improve the strength of the model.

This paper will demonstrate that the gravity model’s predictions can be improved through different measures of distance, the exclusion of contiguity, and regional sub-sampling over both cross sectional and panel data to estimate the impact of trade on income. First, I find that several alternative distance measures of distance on trade do not have enough variation to produce meaningfully different coefficients for world trade. Second, regional sub-samples of the gravity model, and to a lesser degree trade on income, significantly improve the overall results. Third, the effect of trade on income is regionally sensitive.

The gravity model posits a negative relationship between bilateral trade and distance while accounting for economic size and country characteristics such as population, area, and output. Newton's Law of Universal Gravitation for objects i and j is given by equation 28.

$$(28)\ Force = \frac{Mass_i * Mass_j}{dis\tan ce_{ij}^2}$$

In the physical, the mass is constant, but not so when applied to economic activity. There are two main explanations or channels for the spatial interaction between trade and distance: transport costs and complementarity. The latter includes cultural, linguistic, and religious familiarity as well as issues of risk aversion. Exchange requires both production differentiation on the supply side, but specific complementarity of demands (Ullman, 1980). Spatial interaction is based on the concept of situation, which is the horizontal relationship of an effect in one area on another area (ibid, p 13). Site is a vertical relationship that refers to the "local, underlying areal conditions" and neither concept can be viewed in isolation (ibid). There is an empirically well-established negative relationship between trade and distance after controlling for size. As distance increases, transportation costs increase and familiarity decreases, both of which reduce trade.

In concluding their study of the affects of trade on long-run economic growth, Frankel and Romer state

> As a result, geographic variables provide only a limited amount of information about the relation between trade and income. Thus, unless additional portions of overall trade that are unaffected by other determinants of income can be identified, it is likely to be difficult to improve greatly on our estimates of the effects of trade. (Frankel and Romer, 1999, p 395).

Due to the high spatial correlation of residuals in the gravity model for trade, I will show that geographic variables may provide more information about the relation between trade and growth than Frankel and Romer (1999) indicate, when an economically-weighted distance measure is used. Secondly, the robustness of geographic variables improves greatly when concentrating on regional trade. The modified gravity model of Frankel and Romer is relatively poor at modeling bilateral trade for the entire world, but when the world is stratified into geographic regions the results improve greatly—spatial interactions are not entirely captured by distance alone.

The organization of this paper is as follows. Variations of the gravity model's distance specifications are in section 2. Section 3 is a review of the literature concerning the relationships between trade, income, and distance as well as an econometric application of the gravity model to isolate the pertinent relationships. Section 4 discusses data sources and empirical estimation methods. Section 5 presents the gravity model results starting with the model of Frankel and Romer (1999) and then adjusts the variables and adds four more cross sections of time. Section 6 estimates the reduced gravity model from section 5, but with panel data from 1980 to 2005. The following section introduces a spatial view of trade including the role of spatial dependence in the trade on income results for 1985. Section 8 presents the modified gravity model's estimation results for the panel data, including region sub-samples. As a result of spatial dependence, several smaller regional models are used to test the robustness of the IV technique to estimate the effects of trade on income. Sections 9-11 present the final results or second stage to assess the importance of trade on income. Section 9 uses instruments generated in section 5—the Frankel and Romer version as well as the updated cross sections. Sections 10 and 11 presents the final results for panel data of the whole world and for the regional models. Section 12 concludes.

2. Distance Literature

The strength of the gravity model hinges on the validity of the distance measure. Distance may be measured between borders or edges of countries or between internal midpoints. Contiguous states are usually treated with a discrete variable, although continuous distance measures are sometimes employed. Even contiguity measures suffer subjective determinations due to countries separated by minor stretches of water or having disjoint enclaves (Gleditsch and Ward, 2001, p 742).[29] Other approaches treat the distance between neighboring countries as fractions of distances to country centers although this approach has been severely criticized (Head and Mayer, 2002, p 10). There remains no theoretically justified reason to treat adjacency separately according to Head and Mayer (2002). Otherwise, distance between two aggregated areas is usually based on internal points. The choice for the point include principle cities and capital cities and for centroids of population centers or economic centers. The great circle (arc) distance is easy to calculate using the Haversine Formula for all points and better proxies the distance for air freight without systematically distorting distance for land or sea carriage.

[29] Examples of minor stretches of water include USA and Cuba and Sweden and Denmark and for disjoint enclaves: Alaska (USA), Kaliningrad (Russia), and Cabinda (Angola). Conversely, Singapore and Malaysia are considered contiguous, in spite of a minor stretch of water between them.

The choice of "which point" remains important and for large and small countries it can have a significant impact. For small countries, the principle city is almost always the capital city and the population and economic centers differ little from these cities. For approximately thirteen countries the capital differs from the principle city or there exists multiple seats of government.[30] The difference between the population and economic centers from the capital and principle cities increases with country size. Even relatively objective points like principle cities and capitals require some subjective reasoning on the part of the researcher if distances between points are important.

Gleditsch and Ward (2001) develop a database on the minimum distance between dyads of states for all countries less than 950 km apart from 1875 to 2001. These measures incorporate both measures of contiguity and continuous distance measures. Due to the complexity of calculation methods, their dataset is restricted to countries within 950 km of each other and thus not used here.

Nitsch suggests that the distortions between city pairs (or any centroid) are most severe for countries close together. "...the widely used and fairly undisputed procedure of approximating international distances by the distance between a single pair of cities can produce misleading results" (Nitsch, 2001, p 9). The problem depends on the size, shape of the country, and urban concentration.

To correct for the distortion of influential observations, Nitsch calculates the international distance between Germany and Austria using a weighted sample of the

[30] Examples of the former include: USA (Washington DC), Brazil (Brasilia), Australia (Canberra), and Canada (Ottawa) and Bolivia is an example of the latter. Some countries have even changed capitals: Myanmar and Cote d'Ivoire are examples.

distance between city pairs. The results could even be calculated for the five largest cities in each country, but Nitsch only advocates this procedure for adjacent countries due to the computational difficulties of broadly expanding the sample (ibid, p 10).

Head and Mayer (2000) use a simple weighted arithmetic average over all region-to-region distances inside a country. They use GDP shares as the weights, wj. With R denoting the number of regions, country i's distance to itself is given by equation 29.

$$(29)\ d_{ij} = \sum_{j=1}^{R} w_j \left(\sum_{k=1}^{R} W_k d_{jk} \right)$$

Based on sub-national data on trade volumes, Head and Mayer (2002) construct a measure of effective distance based on economic centers. The authors derive a constant elasticity of substitution (CES) index of effect distance weighted by regional trade volumes and given by equation 30 (p12-13).

$$(30)\ d_{ij} = \left(\sum_{k \in i} \left(\frac{y_k}{y_i} \right) \sum_{l \in j} \left(\frac{y_l}{y_j} \right) d_{kl}^{\theta} \right)^{\frac{1}{\theta}}$$

The value of theta, θ, is sometimes assumed to be 1, however Head and Mayer's (2002) review of hundreds of gravity equations find in most cases that it is approximately -1. Thus, theta is estimated by taking the general mean of the weighted average mean (when θ = 1) and the harmonic mean (when θ = -1) (p 13). Where *i* and *j* are states and *k* and *l* are districts within those respective states, *d* is effective distance, and *y* is income. While the above measure reduces to the arithmetic mean in Head and Mayer (2000), arithmetic means are usually less than harmonic means, thus arithmetic mean distances overstate effective distances (p 13).

While the distance variable underpins the gravity model, researchers disagree on the most accurate measure of distance. When applied to a large cross section of countries, each of the measures is statistically robust, however, in modeling proximity of economic activity, an economically-weighted measure of distance is most appropriate. The Head and Mayer (2002) weighted distance with the constant elasticity of substitution correlates highly with other measures of distance (see Appendix 8), yet the economically-weighted measure of distance is a better theoretical choice to measure economic activity amongst the measures available for a large cross section of countries.[31]

3. Back to Gravity

One of the most studied topics in economics is the gains-from-trade model dating back to Adam Smith and David Ricardo. The idea that free trade is beneficial for income and growth garners an incredibly high consensus from economists (Caplan, 2002). There are two main problems with empirical estimates to explain economic growth, almost everything has been shown to be an effective predictor of growth such as economic freedom, low taxes, high human capital, "good" institutions, et cetera. Secondly, the effects of trade on income is subject to endogeneity—empirical specifications with endogenous relationships. Both trade and income are endogenous where they influence each other and thus causality cannot be determined: trade leads to higher incomes, but rich countries also trade more. For instance, countries that adopt free market policies might also adopt stable monetary and fiscal policies, which should lead independently to

31 All five of the distance measures correlate 99% with each other.

higher growth rates. Likewise, countries with a high degree of rule of law and protection of property rights—good institutions, also have higher growth rates and higher incomes (Dollar and Kraay, 2003; Glaeser, et al., 2004).

The gravity model can be used to untangle the endogeneity between trade and income through developing instrumental variables to be used in a 2-Stage Least Squares (2SLS) or instrumental variables (IV) regression. A "good" instrument is one that has a relationship with the regressor (trade), but not the regressand (income). Gravity models use the distance between two countries to explain trade (Anderson, 1979). As distance increases between countries *i* and *j*, home and foreign, transaction costs increase, the number of intervening opportunities increases, and transferability decreases—all of which reduce trade. Generally, larger countries attract more trade and thus there is a positive relationship between trade and country size measured by area, population, or output. While government policies would affect trade and income, the distance between countries is not affected by government policies and it does affect trade. Thus, geographic characteristics, such as distance, can be used to create instrumental variables to estimate the effect of trade on income.

A gravity equation in economics typically takes the form of

(31) $trade_{ij} = distance_{ij} + size_j + \varepsilon$

There is an expected negative coefficient on distance and a positive coefficient on size. However, the gravity model is unable to distinguish between good and bad trade relationships: estimates are subject to trade distortions.

4. Data and Methods

The two-stage estimation procedure, instrumental variables, requires first the gravity model estimation of bilateral trade flows and secondly data on country characteristics including trade openness and income. The bilateral trade data are drawn from the Direction of Trade Statistics (DOTS) from the International Monetary Fund (IMF, 2007). These data cover all imports and exports between 199 countries from 1980 to 2005. Income, population, area, and human capital data covering 210 countries come from the World Bank's World Development Indicators (WDI) (WorldBank, 2006). The third major source of data is Centre D'Études Prospectives et D'Informations Internationales (CEPII) from whom distance measures were attained (Mayer and Zignago, 2002). In sum, the data cover 174 countries from 1980 to 2005. Cross sectional results are presented for five-year intervals beginning in 1985 and ending in 2005. For the second stage of the regressions, a second dataset is employed with a panel of countries, instead of the large bilateral trade dataset. The sources are the same as noted above. Data descriptions are available in Appendix 3 and summary statistics are presented in Appendix 4.

Following previous work that uses the gravity model to create instrumental variables to test the effect of trade on income, I first estimate the gravity equation using equation 32 below. Then I use the fitted values for the estimates on income in the second stage (Dollar and Kraay, 2003; Frankel and Romer, 1999; Frankel and Rose, 2002). The techniques initially mirror those of Frankel and Romer (1999), henceforth FR, and then the regression estimates are updated and expanded to include additional time periods and regional sub-samples.

$$(32)\ trade_{ij} = distance_{ij} + pop_i + area_i + pop_j + area_j + ll_j + border_{ij} + border*pop_i + border*area_i + border*pop_j + border*area_j + border*ll_j + \mu$$

Where *i* is the home country, *j* is the foreign country, *ll* is landlocked dummy variable and *border* is dummy variable for countries *i*, *j* sharing a common land border (contiguous).

5. Using Gravity for Good

The first stage results using the same methodology as Frankel and Romer (1999) are presented in column (1) of table 11 and the first stage results in column (2) are generated from a fixed effects estimator and the geographically-weighted distance between countries for distance. The fixed effects estimation groups observations by home country *i* for analysis.[32] A common border dummy, or contiguity, and its interaction terms are included in both columns (1) and (2) to isolate trade with each countries' neighbors and not just proximate countries as given by equation 32 (Jeffrey A Frankel & Romer, 1999, p 383).

32 A Hausman test confirmed the appropriateness of fixed effects over random effects. FR use OLS and treat every observation as completely independent from each other.

Table 11. Bilateral Trade Equation for 1985

	(1) FR	(2) Nelson
$Distance_{ij}$	-1.12***	-1.19***
	(0.05)	(0.05)
$Population_i$	-0.03	-0.10*
	(0.03)	(0.06)
$Area_i$	-0.17***	-0.16***
	(0.02)	(0.05)
$Population_j$	1.00***	0.99***
	(0.03)	(0.03)
$Area_j$	-0.30***	-0.30***
	(0.02)	(0.02)
Landlocked	-0.34***	-0.36
	(0.12)	(0.22)
Contiguous	2.18	1.51
	(1.88)	(1.86)
Contig*$Distance_{ij}$	0.38	0.30
	(0.33)	(0.32)
Contig*Pop_i	-0.20	-0.20
	(0.19)	(0.17)
Contig*$Area_i$	0.09	0.13
	(0.19)	(0.18)
Contig*Pop_j	-0.26	-0.20
	(0.16)	(0.16)
Contig*$Area_j$	-0.11	-0.11
	(0.17)	(0.16)
Contig*Landlocked	0.07	0.04
	(0.38)	(0.38)
Constant	-1.57***	-0.36
	(0.48)	(0.59)
Observations	4,951	4,951
R-squared	0.31	0.31
Number of Countries		126

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable is nominal trade/nominal GDP (both in USD)

There are a few differences from the original FR results. Namely, *distance* has a larger negative coefficient than in the FR article. Most of the statistically significant estimates are similar between these studies, however, the dataset used here includes approximately one-third more observations as well as revised and expanded data. Trade as a share of GDP in 1985 is slightly higher between contiguous countries than non-contiguous countries; the effect is diminished when controlling for home country (2).

Although column 2 uses the economically-weighted distance and a slightly different estimation technique, the coefficient estimates have a high degree of correlation. A one percent increase in the distance between a pair of countries reduces trade by 1.2 percent. It is also interesting to note that the population of the destination country (j) is positively correlated with trade with the population of the exporting country (i) is negatively associated with trade: trade often flows from small to large markets. Neither contiguity, nor any of the "border" interactions were found to be significant.

Subsequent regression estimates in five-year intervals using the fixed effects regression estimator are presented in table 12. The numbers of observations nearly doubles from the 1985 cross section to the 2005 cross section. Clearly, the rise in observations owes to better data collection, increased prevalence of international trade, and perhaps most importantly the increase in the number of countries post-Cold War. In every instance the distance variable is statistically significant and negative ranging from -1.19 to -1.44 and steadily increasing at each interval. Although transportation and information costs have fallen from 1985 to 2005, the distance between potential importers and exporters is having a stronger negative impact on trade. The increase in competition and substitutability of goods means that consumers have more potential producers from whom to purchase goods. Producers within countries are producing a greater variety of goods that increases spatial competition. Both the population and area of the destination country *j* are statistically significant throughout, but each coefficient estimates increases steadily over the period.

Table 12. Bilateral Trade Equation, 5 Year Intervals, Fixed Effects

	(1) 1985	(2) 1990	(3) 1995	(4) 2000	(5) 2005
$Distance_{ij}$	-1.19***	-1.25***	-1.23***	-1.32***	-1.44***
	(0.05)	(0.05)	(0.04)	(0.03)	(0.04)
$Population_i$	-0.10*	-0.11*	-0.06	-0.04	-0.03
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
$Area_i$	-0.16***	-0.12**	-0.10**	-0.09*	-0.06
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
$Population_j$	0.99***	1.17***	1.22***	1.23***	1.30***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
$Area_j$	-0.30***	-0.38***	-0.41***	-0.41***	-0.42***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Landlocked	-0.36	-0.38	-0.19	-0.12	-0.45**
	(0.22)	(0.24)	(0.19)	(0.18)	(0.19)
Contiguous	1.51	1.59	0.72	1.92*	1.29
	(1.86)	(2.06)	(1.58)	(1.17)	(1.14)
Contig*$Distance_{ij}$	0.30	0.86***	0.54	0.62*	0.80*
	(0.32)	(0.30)	(0.35)	(0.36)	(0.42)
Contig*Pop_i	-0.20	-0.46***	-0.44***	-0.49***	-0.48***
	(0.17)	(0.18)	(0.12)	(0.12)	(0.13)
Contig*$Area_i$	0.13	0.15	0.08	0.08	-0.02
	(0.18)	(0.19)	(0.14)	(0.13)	(0.14)
Contig*Pop_j	-0.20	-0.29**	-0.20	-0.14	-0.23**
	(0.16)	(0.14)	(0.13)	(0.11)	(0.11)
Contig*$Area_j$	-0.11	-0.15	0.13	-0.00	0.09
	(0.16)	(0.18)	(0.16)	(0.14)	(0.15)
Contig*Landlocked	0.04	-0.02	0.17	-0.10	0.32
	(0.38)	(0.37)	(0.27)	(0.23)	(0.23)
Constant	-0.36	-1.15*	-2.27***	-2.13***	-1.71***
	(0.59)	(0.63)	(0.54)	(0.50)	(0.55)
Observations	4,951	5,696	7,823	9,288	9,493
Number of Countries	126	130	151	155	152

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable is nominal trade/nominal GDP (both in USD)

The estimates for population *j* increased from 0.99 to 1.30 from 1985 to 2005 indicating that the population of the destination market had a stronger positive effect on trade in 2005 than previously. On the contrary, the coefficient of the area of the destination market decreased, from -0.30 to -0.42 from 1985 to 2005. Both trends occurred as countries are becoming more populous, yet there are more countries. Trade with smaller countries increased through the 1990s as the number of small countries flourished and the trade share (of GDP) of larger countries decreased. The negative coefficient for being landlocked for all cross sections further confirm the benefits of sea versus land carriage as elucidated by Smith and in spite of technological improvements and infrastructure investment that continue to lower transportation costs (Smith, 1776 [1909]). The negative coefficient on trade for landlocked countries ranged from -0.12 to -0.45 from 1985 to 2005: lower transportation costs and better infrastructure do not seem to be alleviating transportation burdens for landlocked countries.

If the contiguity interaction terms are dropped, then the gravity estimation becomes equation 33. Head and Mayer (2002) argue that contiguity measures have no independent effects from distance on trade. While the estimation results from equation 32 failed to show heteroskedasticity due to the inclusion of distance, contiguity, area, and population, it remains possible.

Sharing a land border does not mean there is a transportation network joining the countries: not all borders are equal. The border between the US and Canada has many rail and auto crossings while the border between India and China has little infrastructure and carries little of the trade between the countries. The distance between the most populous cities of the US and Canada is 548 kilometers and the distance between the most populous cities of India and China is 3,785 kilometers, yet the contiguity dummy and contiguity interactions treat the relationships equally.[33] The contiguity dummy and its interactions may be useful for estimation of "border effects" but is not necessary for a worldwide gravity model, nor due to possible heteroskedasticity.

(33) $trade_{ij} = distance_{ij} + pop_i + area_i + pop_j + area_j + landlocked_j + \mu$

Excluding the contiguity dummy variable and its interactions in equation 33 barely alters the overall estimates for each of the five-year intervals, see in table 13 . As expected, distance, area (j), and landlocked have negative coefficients, while population (j) has a positive coefficient. There are more observations from the updated dataset, a similar overall fit and coefficients to Frankel and Romer's.

The gravity model in equation 33 relaxes the model of Frankel and Romer (1999) to exclude the "border effects" due to their lack explanatory power. Furthermore, the population controls are dropped to include countries of any population. The specifications from equations 32 and 33 produce very similar results—as expected. The gravity model, again, indicates a negative relationship between distance and trade and a negative effect on trade for landlocked countries. The strength of the gravity model endures even when sparsely populated countries, for whom there is data, are included.

[33] Other measures of distance do not change the disparity.

Table 13. Gravity Model without Contiguity Interactions and Population Controls

	(1) 1985	(2) 1990	(3) 1995	(4) 2000	(5) 2005
$Distance_{ij}$	-1.20***	-1.28***	-1.33***	-1.40***	-1.49***
	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
$Population_i$	-0.12**	-0.13**	-0.09	-0.07	-0.06
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
$Area_i$	-0.13***	-0.08	-0.06	-0.08*	-0.06
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
$Population_j$	0.96***	1.13***	1.18***	1.20***	1.27***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
$Area_j$	-0.28***	-0.35***	-0.38***	-0.38***	-0.41***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Landlocked	-0.36	-0.36	-0.15	-0.12	-0.45**
	(0.23)	(0.24)	(0.20)	(0.18)	(0.20)
Constant	-0.37	-1.17**	-1.62***	-1.19**	-0.86*
	(0.54)	(0.56)	(0.50)	(0.46)	(0.52)
Observations	5,114	5,933	8,097	9,505	9,734
Number of Countries	130	134	155	158	154

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable is nominal trade/nominal GDP (both in USD)

Starting with a modified gravity model like Frankel and Romer (1999), I show the same basic results using the same specification, then use a fixed effects estimation for updated data for additional cross sections and using an economically-weighted distance measure is used instead of the distance between capitals. Finally, a reduced model that excludes the contiguity dummy variable, the continuity interactions with other independent variables, and relaxes the population constraints on countries with less than 100,000 inhabitants is estimated to produce similar results. All-in-all, the basic results of Frankel and Romer (1999) hold for a variety of specifications and these results will be used as instrumental variables in the second stage of the regression to estimate the effect on long-run income.

6. Gravity Model: Panel Data

Instead of comparing five cross sections of data, a panel of the entire range of years (1980-2005) can be tested using a fixed effects estimator for all years.[34] Unlike Frankel and Romer (1999) who fix for a single year and only analyze a single year of data, I have fixed by country in the cross-section and panel data. Table 14 presents the panel data, 1980-2005, of the gravity model excluding all of the interaction terms, equation 33.

Table 14. Gravity Model, Fixed Effects, Panel Data, 1980-2005

	(1)
$Distance_{ij}$	-1.36***
	(0.01)
$Population_i$	-0.68***
	(0.04)
$Area_i$	0.00
	(0.00)
$Population_j$	1.15***
	(0.00)
$Area_j$	-0.36***
	(0.00)
Landlocked	0.00
	(0.00)
Constant	3.23***
	(0.40)
Observations	186,534
Number of Countries	165
R-squared	0.36

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable is nominal trade/nominal GDP (both in USD)

[34] Hausman test was performed and confirmed that the fixed effects estimator is more appropriate than the random effects estimator.

The fixed effects estimator drops variables that are time invariant, thus *Landlocked* and $Area_i$ are dropped because the home countries are grouped together, instead of fixing by time. The overall R-squared of 0.36 is nearly identical to the estimate of Frankel and Romer (1999) of 0.37. The coefficient estimates for $Distance_{ij}$ and $Population_j$ in table 14 are almost the same as those in table 13. However, all variables are now statistically significant, owing to the massive number of observations. Increases in home country population reduce trade, while an increase in population *j* increases bilateral trade, however increases in area *j* reduce trade. Even though the panel data cannot estimate the coefficients of time-invariant variables, such as the area of the home country or being landlocked, the remaining results squarely align with the cross-sectional results from tables 13 and 14.

7. A Spatial View of Trade

> As a result, geographic variables provide only a limited amount of information about the relation between trade and income. Thus, unless additional portions of overall trade that are unaffected by other determinants of income can be identified, it is likely to be difficult to improve greatly on our estimates of the effects of trade. (Frankel and Romer 1999, p 395).

Geographic variables provide additional information about the relationship between trade and income, when first the spatial variation of trade's effect on income is assessed. The existence of spatial effects, namely, spatial dependence requires a spatial structure underlying the spatial correlation. The underlying structure of spatial correlation of residuals for the estimates of trade on income demonstrate the limitations of the model as well as provide a venue to refine the estimates of the income and growth effects of trade.

Spatial dependence for the overall effect of trade on income can be shown through the mapping of the residuals. Figure 9 does just that. More specifically, figure 9 is a map of the standard deviations of the residuals that uses equation 32 for the first stage of the estimation for the 1985 cross section.

If the colors are evenly scattered, there is not spatial dependence and no role additional spatial analysis. However, regional clusters of colors indicate the presence of spatial dependence. These clusters indicate consistent regional deviations from the median estimates. If the residuals displayed spatial dependence, how would region-based instruments affect overall trade on income estimates?

Countries in white are missing from the dataset, while those in yellow are within 0.5 standard deviations. These are the countries from which the model produces the least biased results. Countries in orange, brown, and dark brown have residuals one, two, and three standard deviations from the median indicating the model overstates the benefits of trade on income in these countries. On the other hand, countries in green have residuals one standard deviation above the median estimate. The model understates the benefits of trade on income for countries in green. Concerning the spatial distribution of the residuals, approximately half residuals for countries in Africa are within a standard deviation of the median estimates—the model does well for half of Africa. All of the remaining African countries have residuals below the median. Europe has two countries at the median, Belgium and Hungary and two countries below the median, Luxembourg and Bulgaria. Otherwise, all of the other European countries are above the median. The rest of Asia is at of below the median with the exceptions of Japan and South Korea. Both Australia and New Zealand have residuals well above the median. All of the future NAFTA countries have residuals well above the median. Central and South America has three countries with standard deviations below the median, Honduras, Panama, and Guyana. The rest of Central America is in the median category, except for Costa Rica, which is above the median. South America including at the economic powerhouses of Brazil and Argentina are above the median. The results for South America, in general, overstate the benefits of trade on income. The results for the effect of trade on income, following the Frankel and Romer (1999) methodology for data for 1985 indicate more clear spatial correlations. Europe, the Americas, Japan, South Korea, Australia, and New Zealand have benefited more from trade than the median country has. In particular, Africa and much of Asia does not seem to have benefited as a result of trade as much as the median country.

Because of the spatial clustering of residuals, two region-based models are tested. A total of nine regions were gathered primarily based on geographic categories from the country groupings of the World Development Indicators (WorldBank, 2006).[35] Seven of the country groups are geographic regions and two groups are economic regions. A full listing of the country groups can be found in Appendix 5.

[35] The regions are East Asia and Pacific, South Asia, Middle East and North Africa, Sub-Saharan Africa, OECD countries, Latin America and Caribbean, ASEAN countries, Pacific Rim countries, and Europe.

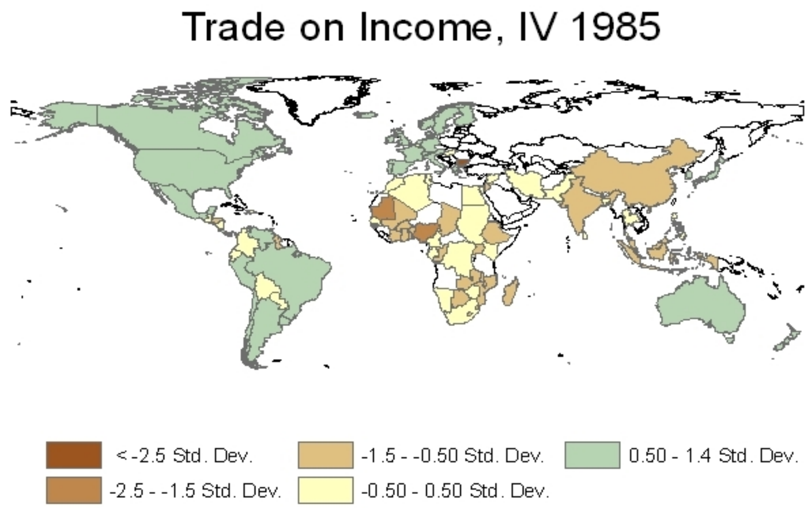

Figure 9. Standard Deviations of Residuals of Trade on Income 1985

Using these regional categories, the model is modified and tested for all trade within a region, such from a country in Region A to another country in Region A and for inter-region trade, that is from any country in Region A to another country in any other region (non-A). The reduced or traditional gravity model (equation 33) was used to generate equations 34 and 35 that exclude the contiguity dummy variable, its interactions , and population controls. Contiguity measures are not appropriate when examining intra- and inter-region trade. Countries within a geographic region overwhelmingly share national borders leading the variable to be dropped for nearly all observations in a regression whether trade within a single region or between regions.

Intra-Region Trade Equation

(34) $trade_{ij} = distance_{ij} + pop_i + area_i + pop_j + area_j + landlocked_j + \mu$

i is the home country, *j* is the foreign country, where *i*, *j* are in the same region

Inter-Region Trade Equation

(35) $trade_{ik} = distance_{ik} + pop_i + area_i + pop_k + area_k + landlocked_k + \mu$

i is the home country, *k* is the foreign country, where *i*, *k* are not in the same region

These data are not disaggregated by industry, however at the all-industry level questions of whether countries intra-regions tend to produce substitutes or complements naturally arise. For instance, if all exports from South America were an agricultural commodity, such as bananas, then exports from each country would be largely substitutes for each other. Bananas from Brazil would have a high degree of substitutability for bananas from Ecuador. First, trade volume would be much lower for intra-region trade, than inter-region trade. Secondly, agricultural goods especially tend to exhibit greater variation as distance increases and then diminishes—agricultural goods tend to be produced at the same latitudes. If countries within a region are all producing substitutes, then the gravity model will have greater explanatory power for inter-region trade. Countries within a region producing complements will have relatively more intra-region trade and a relatively higher explanatory power of the gravity for intra-region trade.

8. Empirical Results Panel Data and Regional Gravity Model

Intra-region trade considers each region as the entire world—all other countries are excluded. Whereas, inter-region trade drops all intra-region trade to treat each region as a single country to assess all trade external to the region. The intra-region trade estimates are used in the second stage to calculate the effect of trade on income solely for that region. The inter-region trade simplifies the effects of trade on income to improve the estimates using geographically defined relationships. The intra-region and inter-region trade models, from equations 34 and 35, for the entire panel of data are presented in tables 15-18.

Distance has a clear, consistently significant, and negative effect on bilateral trade where coefficient estimates range from -1.0 to -2.01 for all specifications of intra-region trade, tables 15 and 16. Trade within OECD countries suffers the least from distance which is consistent with the stylized fact that transportation costs are relatively low between Europe and the US. Meanwhile, the effect of distance in deterring trade for Europe decreases to -1.53, indicating that transportation costs are only especially low for Western Europe and the US, but not trade within all of Europe.

Table 15. Intra-Region, Fixed Effects, Panel Data, 1980-2005

	EAP	SASIA	MENA	SSA	OECD
$Distance_{ij}$	-2.01***	-1.91***	-1.38***	-1.65***	-1.00***
	(0.05)	(0.21)	(0.06)	(0.03)	(0.01)
$Population_i$	3.59***	0.76	2.68***	0.50***	1.37***
	(0.32)	(0.57)	(0.24)	(0.14)	(0.20)
$Area_i$	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$Population_j$	1.07***	1.38***	0.46***	0.59***	0.76***
	(0.03)	(0.12)	(0.05)	(0.03)	(0.01)
$Area_j$	-0.36***	-0.67***	-0.16***	-0.07***	0.11***
	(0.03)	(0.11)	(0.04)	(0.02)	(0.01)
Landlocked	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-31.36***	-7.96	-23.28***	-4.90***	-18.62***
	(3.18)	(6.24)	(2.23)	(1.22)	(1.92)
Obs	1,947	376	1,490	8,903	6,379
Number of countries	15	6	13	40	23
R-squared	0.65	0.58	0.32	0.26	0.82

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable is trade/gdp

Table 16. Intra-Region, Fixed Effects, Panel Data, 1980-2005

	LAC	ASEAN	PACRIM	EUR
$Distance_{ij}$	-1.94***	-1.82***	-1.47***	-1.53***
	(0.03)	(0.13)	(0.02)	(0.02)
$Population_i$	1.70***	4.90***	1.72***	-5.37***
	(0.16)	(0.54)	(0.16)	(0.35)
$Area_i$	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
$Population_j$	0.80***	1.69***	1.26***	0.73***
	(0.03)	(0.15)	(0.02)	(0.01)
$Area_j$	0.03	-0.84***	-0.37***	0.10***
	(0.02)	(0.06)	(0.01)	(0.01)
Landlocked	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-14.78***	-49.33***	-18.32***	44.45***
	(1.44)	(5.46)	(1.56)	(3.11)
Obs	7,581	598	9,874	11,358
Number of countries	25	7	31	37
R-squared	0.51	0.47	0.56	0.52

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable is trade/gdp

The coefficients of population of the home or the foreign country are generally positive, except for Europe where less populated countries trade more. In addition to Europe, South Asia and Africa have larger coefficients for foreign population have home population indicating that an increase in the home country population will induce smaller trade increases than for the same percentage increase in the foreign country population. The data confirm that trade, exports or imports, from South Asia, Africa, and Europe are more sensitive to foreign country population changes than for the home country. Foreign country size has a positive effect on within-region (as a share of GDP) for all regions. The area of the home country, *i*, and the dummy variable *landlocked* are time-invariant and therefore, dropped from the fixed effects regression estimates. The area of the foreign country, *j*, generally has a negative coefficient. An increase in the physical size of the foreign country reduces trade, as expected.

The gravity model results for the panel dataset from 1980 to 2005 fit the theoretical predictions and previous estimates, even after restricting the observations to countries in the same region as each other.

Collapsing countries into regions shifts attention to trade for complementary goods. Trade between regions requires greater distances for commerce which introduces more possible substitutes. The results for inter-region trade are presented in tables 16 and 17. The effects of distance on trade remain clearly negative with coefficients ranging from -0.49 to -2.27 for ASEAN countries and Latin America and Caribbean countries, respectively. For trade between ASEAN countries and all other countries, an increase in distance reduces trade, but only slightly compared to other regions. The same increase in distance to export or import market reduces trade 4.5 times more for Latin America and Caribbean countries. The coefficient for home country population is negative except for South Asia and ASEAN countries. Yet the coefficients for foreign country population, *k*, are all positive, and coefficients for size of *k* are all negative. Inter-regional trade increases as a result of increasing the foreign country population, *k* and decreases from increases the physical size of the foreign country, as expected.

For Latin America and Caribbean (developing) countries distance and foreign population have significant negative and positive effect, respectively. Once again, trade diminishes with distance and increases with the size of the destination market. Unlike

Africa, distance has a larger negative effect on trade for inter-region trade. To explain the large distance decay, consider the main destination markets for South American goods, especially produce: U.S., Europe, and Japan. Europe and Japan have much closer sources of competing goods such as Africa, and the Middle East, and East Asia, respectively. Furthermore, one tends to see these countries exporting to countries with relatively high population densities. All of these effects remain for trade outside of the region, though the overall fit drops for trade outside of the region.

Table 17. Inter-Region Gravity Model, Fixed Effects, Panel Data, 1980-2005

	LAC	ASEAN	PACRIM	EUR
$Distance_{ik}$	-2.27***	-0.49***	-1.63***	-0.78***
	(0.03)	(0.08)	(0.03)	(0.02)
$Population_i$	-1.50***	0.61***	-1.68***	-3.57***
	(0.12)	(0.20)	(0.11)	(0.30)
$Area_i$	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
$Population_k$	1.37***	1.19***	1.05***	1.10***
	(0.01)	(0.03)	(0.01)	(0.01)
$Area_k$	-0.53***	-0.30***	-0.34***	-0.27***
	(0.01)	(0.02)	(0.01)	(0.01)
Landlocked	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Constant	19.28***	-17.71***	17.27***	22.83***
	(1.17)	(2.28)	(1.16)	(2.67)
Obs	26,548	6,765	33,593	40,844
Number of Countries	26	8	31	37
R-squared	0.32	0.31	0.26	0.42

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable is trade/gdp

Comparing between the intra- and inter-region trade models, the effect of distance in reducing trade is higher for four regions. The four regions where trade decreases more trade within the region than outside of it for a given increase in distance are ASEAN countries, Sub-Saharan Africa, Europe, and South Asia. Both ASEAN countries and Europe, and to a lesser degree South Asia have relatively high levels of trade with North America, which is much further away than within-region neighbors, thus inter-region trade has a smaller coefficient on distance than intra-region trade.

Table 18.Inter-Region Gravity Model, Fixed Effects, Panel Data, 1980-2005

	EAP	SASIA	MENA	SSA	OECD
$Distance_{ik}$	-1.75***	-1.20***	-1.39***	-0.82***	-1.30***
	(0.04)	(0.05)	(0.03)	(0.04)	(0.01)
$Population_{i}$	-0.17	0.47***	-1.82***	-0.64***	-2.21***
	(0.17)	(0.16)	(0.15)	(0.08)	(0.21)
$Area_{i}$	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$Population_{k}$	1.05***	1.17***	1.34***	1.17***	0.97***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
$Area_{k}$	-0.26***	-0.40***	-0.42***	-0.39***	-0.26***
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Landlocked	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	2.93	-9.20***	12.26***	-1.24	17.47***
	(1.87)	(1.91)	(1.35)	(0.80)	(2.04)
Obs	13,568	9,018	10,376	23,899	40,177
Number of Countries	15	7	14	40	24
R-squared	0.33	0.37	0.34	0.25	0.43

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable is trade/gdp

Sub-Saharan Africa (Africa) is relatively under-developed in terms of infrastructure, creating higher transportation costs for trade within Africa relative to trade outside of Africa. This trade penalty means that an increase in distance more severely reduces trade amongst African firms than for trade between African and non-African firms. The coefficient estimates for the largest region, the Pacific Rim, are similar for the intra- or inter-region models at -1.47 and -1.63, respectively. The intra-region trade covers a vast area, but inter-region trade requires similar distances and in turn, inter-region trade is hardly diminished.

The divergence between the inter-region distance coefficients for ASEAN countries and East Asia and Pacific Rim (EAP) countries is explained by the differences of composition of each group. EAP includes both Pacific Islands and China, while ASEAN includes Singapore. Because Singapore is a regional and international transportation center the distance coefficient is smaller for the group including Singapore (ASEAN). The distance coefficients for the Pacific Rim are consistent with the hypothesis of distance decay and increased competition from substitutes over space.

The sub-sampled gravity estimates for trade confirm that regional sub-samples generally better allow the model to explain the spatially complex trade flows. Secondly, intra-region trade is much better explained than inter-region trade. Both of these lead one to consider the decaying effect of distance. As distance between potential trading partners increases so does the possible number of intervening opportunities. The intra- and inter-region trade estimates are used to estimate the effects of trade on income in the second stage of the regression.

9. Trade and Income

The constructed trade share of the fitted values from each of the bilateral trade equations is used to estimate of the geographic component of each country's overall trade share. The constructed trade share appropriately serves as an instrument since it is the excluded exogenous variable that is uncorrelated with the other exogenous variables such as size or population. Equation 36 estimates the effects of trade on income using the constructed trade share generated from the gravity model or the bilateral trade model.

(36) Income = Trade $Share_i$ + $Population_i$ + $Area_i$ +μ

Table 19. Stage 2, IV, Fitted Trade by Year Instrument

	(1) 1985	(2) 1990	(3) 1995	(4) 2000	(5) 2005
Trade Openness	4.06**	4.79***	2.70***	1.76***	1.72***
	(1.99)	(1.47)	(0.71)	(0.41)	(0.45)
Population	0.42	0.42*	0.18	0.09	0.07
	(0.33)	(0.25)	(0.18)	(0.15)	(0.15)
Area	-0.01	0.13	0.05	0.03	-0.00
	(0.20)	(0.19)	(0.13)	(0.12)	(0.13)
Constant	0.61	-1.55	2.98**	4.77***	4.92***
	(3.66)	(3.19)	(1.50)	(1.06)	(1.15)
Observations	97	117	138	139	83
R-squared					0.13

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable is (log) GDP per capita

Frankel and Romer find that increasing the trade share raises income per capita by 1.97 percent and I calculate a value of 4.06 for 1985. After 1990, the effectiveness of trade openness to increase income wanes considerably dropping to 1.72 in 2005. The overall fit is highest for 2005, yet only trade openness is statistically significant—population and country size have no effect on income.

Table 20. IV Regression for Fitted Trade by Year Instrument without Contiguity Interactions, Cross Sections

	(1) 1985	(2) 1990	(3) 1995	(4) 2000	(5) 2005
Trade Openness	3.75**	4.62***	3.74***	2.28***	1.59***
	(1.61)	(1.40)	(1.14)	(0.60)	(0.56)
Population	0.38	0.40*	0.24	0.12	0.07
	(0.29)	(0.23)	(0.21)	(0.16)	(0.14)
Area	-0.01	0.12	0.11	0.07	-0.02
	(0.20)	(0.18)	(0.17)	(0.13)	(0.14)
Constant	1.23	-1.20	0.91	3.63***	5.23***
	(3.03)	(3.00)	(2.29)	(1.35)	(1.34)
Observations	97	117	138	139	83
R-squared					0.16

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable is (log) GDP per capita

The IV estimation results generated from the gravity model that excluded the contiguity interactions and populations are in table 18. The model explained negligible amount of variation in the data for columns (1)-(4) and was not analyzed further. For 2005, the effect of trade openness was slightly lower than in table 17 and much lower than for previous cross sections, though the overall fit was slightly higher.

In figure 10, the standard deviations of the residuals are mapped from the trade on income regression with contiguity interactions or population controls for 2000. This map is the updated and modified version of figure 9, but differs noticeably. Foremost, while the Americas and Europe look largely the same, Africa now includes a few countries with standard deviations of residuals above the median. A few countries in Africa have benefited from trade more than the average prediction of the model. Southeast Asia in reflecting the economic crises that started in 1997, has all countries with residuals one or two standard deviations below the median. While some of the clustering can be explained, such as the Asian Financial Crisis, clusters remain, namely most of West and East Africa, Central and South Asia, and Eastern Europe. By 2000, some former Soviet Republics had thrived as a result of trade, while other continued to struggle in market transitions. Uncertainties remain concerning common causes of the former Soviet clusters and Africa's stagnation.

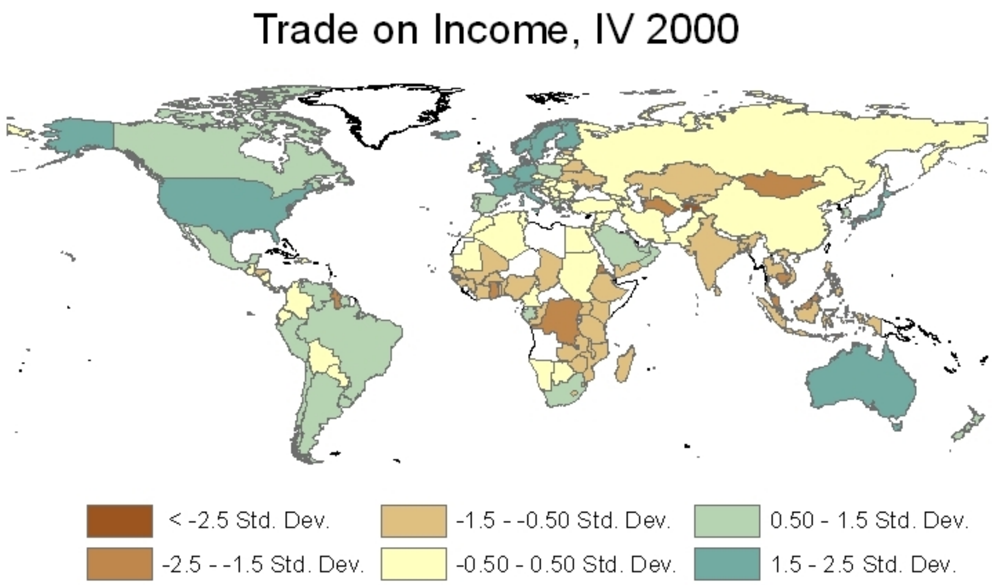

Figure 10. Trade on Income, 2000

Omitting the contiguity interactions changes little the results between tables 18 and 19. The effect of trade on income is slightly higher after omitting the interaction terms as coefficients range from 1.59 to 4.62. There does seem to be a downward trend in the coefficients for *trade share* over time. While more research would need to be done, earlier figures might be higher due to the success for export-led growth through the 1980s, especially by East Asia countries or due to transitional gains elsewhere.

10. Trade and Income Panel Data

Instead of assessing the effect of trade on income cross section-by-cross section and region-by-region, panel data can provide an overall vantage. Panel data from 1980-2005 are used to assess the effect of trade on income using OLS, FE, and IV regressions. The instrument is constructed from the traditional gravity model from table 14, that is without contiguity interactions.

Table 21. Trade on Income Results, Panel Data 1980-2005

	(1) OLS	(2) FE	(3) IV
Trade Openness	0.16***	0.28***	3.32***
	(0.06)	(0.03)	(0.31)
Population	0.04	4.06***	0.24***
	(0.02)	(0.22)	(0.05)
Area	-0.11***	0.00	0.10***
	(0.02)	(0.00)	(0.04)
Constant	8.16***	-30.00***	1.45**
	(0.16)	(1.97)	(0.72)
Observations	3,384	3,255	3,039
R-squared	0.02	0.19	
Number of Countries		150	

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

The OLS estimate shows only weak support for the benefits of trade, while it is a little stronger for the FE estimate, both are statistically significant. The OLS method explains little of the variation of income with a low overall fit. The FE estimation has a relatively strong R-squared and a positive coefficient for population on income. While the fixed effects estimation technique controls for time invariant factors, it does not reduce the endogeneity of trade and income, only the IV method does.

For 1980-2005, the IV results show a strong overall positive effect of trade in increasing income. A one percent increase in trade openness raises per capita income by about 3.32 percent. The effects of population and area are statistically significant, but negligible.

11. Trade and Income Panel Data and Regions

Using the panel data to determine the fitted values for trade by region and then applying those instruments to assess the effect of trade on income for countries in that same region might reduce some idiosyncratic variance. It should be noted that this procedure does not treat each region as an independent and closed system, nor is it possible. Trade tends to be with countries in the same region, though gains from exchange arguably have higher marginally benefits the less similar are the countries. The estimates presented in tables 22 and 23 use trade openness or the share of exports plus imports as a share of GDP as the main independent variable of interest for trade only with countries of the same region. The first stage results are found in tables 15 and 16. The instruments are used to calculate the effect of trade openness on income only for the countries in the region—the intra-region trade instruments are only used for that same region.

The statistically significant results for trade openness the coefficients ranged from -24.12 to 11.65. The strong negative result was for the Pacific Rim countries and the highest value was for Latin American and Caribbean countries. The Pacific Rim includes countries that share a water border, and who are not necessarily neighbors of major trading partners. For instance, trade between Chile and Argentina would not be included while trade between Chile and South Korea would be included, though there are much smaller volumes of the latter. Europe also shows statistically significant negative effect of trade on income due in part to the inclusion of the addition of former Communist states which are rather poor and must develop an export base to integrate into the global economy.

Table 22. Trade on Income Results using Intra-Region Instruments, Panel Data 1980-2005

	(1) EAP	(2) SASIA	(3) MENA	(4) SSA	(5) OECD
Trade Openness	0.31	1.69***	24.18	-0.20	11.94
	(0.42)	(0.22)	(23.08)	(0.62)	(10.97)
Population	0.31***	-0.12	4.31	-0.33***	1.04
	(0.08)	(0.07)	(4.48)	(0.10)	(0.95)
Area	-0.50***	0.16***	-1.53	0.02	1.42
	(0.07)	(0.04)	(1.57)	(0.04)	(1.26)
Constant	9.70***	4.52***	-33.25	8.57***	-25.59
	(0.79)	(0.60)	(41.04)	(1.10)	(31.65)
Observations	199	112	231	805	594
R-squared	0.29	0.85		0.17	

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
The dependent variable is the log of GDP per capita. Trade share, population, and area are in log-form.
EAP: East Asia and Pacific, SASIA: South Asia, MENA: Middle East and North Africa, SSA: Sub-Saharan Africa, OECD: OECD Countries.

The Latin American and Caribbean countries have benefited more than other regions for trade, due to proximity to the US market. While trade with the US is excluded for calculating the instrument, the close and large export market clearly has benefited these countries. The region with the next highest coefficient value, ASEAN countries, at 5.81, includes some of the fastest growing countries that have heavily relied on export-led growth. Population and area coefficients indicate that more populous countries, such as Indonesia and China, and those with relatively smaller territories such as South Korea have higher incomes.

Table 23. Trade on Income Results using Intra-Region Instruments, Panel Data 1980-2005

	(1) LAC	(2) ASEAN	(3) PACRIM	(4) EUR
Trade Openness	11.65***	5.81***	-24.12*	-9.30**
	(3.71)	(1.62)	(13.80)	(3.95)
Population	1.20***	1.81**	0.28	-0.51**
	(0.41)	(0.71)	(0.51)	(0.26)
Area	0.44***	-0.61	-3.05	-1.51**
	(0.16)	(0.38)	(1.87)	(0.65)
Constant	-15.40**	-11.14**	61.22**	39.74***
	(7.27)	(5.59)	(29.53)	(13.16)
Observations	624	131	625	699
R-squared				

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
The dependent variable is the log of GDP per capita. Trade share, population, and area are in log-form.
LAC: Latin America and Caribbean, ASEAN: ASEAN countries, PACRIM: Pacific Rim Countries, EUR: Europe

In comparison, the coefficient for trade share in South Asia is much smaller than East Asia's, albeit statistically significant. South Asia, namely India, has practiced import-substitution and has grown less due to trade than East Asia. Sub-Saharan Africa shows a negative coefficient for trade share on income though it is not statistically significant.

For that matter, there has been little economic growth in Africa and little trade as well. African countries with higher populations have not been able to increase output accordingly, thus there have been declines in real GDP per capita. Estimates for OECD countries suffer from selection bias, but are presented in table 22 (Long, 1988).

Inter-region trade effectively reduces the number of countries and eliminates intra-region trade form consideration to assess the impact of trade on income. Since goods produced within the same region tend to have higher substitutability, goods traded between regions are more likely complements. The instruments generated from the inter-region gravity model in tables 17 and 18 are used to estimate the regional effects of trade openness on income in tables 24 and 25.

Table 24. Trade on Income Using Inter-Region Instruments, Panel Data 1980-2005

	(1) EAP	(2) SASIA	(3) MENA	(4) SSA	(5) OECD
Trade Openness	1.90***	2.58***	-3.46	6.48***	-1.17
	(0.25)	(0.44)	(2.63)	(2.04)	(0.83)
Population	0.13***	0.18***	-0.29	0.48***	-0.11
	(0.04)	(0.04)	(0.21)	(0.17)	(0.07)
Area	0.02	0.05	-0.28**	0.27**	-0.15***
	(0.03)	(0.04)	(0.14)	(0.13)	(0.05)
Constant	4.51***	3.04***	16.01***	-5.33	11.10***
	(0.55)	(0.94)	(5.62)	(4.40)	(1.69)
Observations	3039	3039	3039	3039	3039
R-squared					

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
The dependent variable is the log of GDP per capita. Trade share, population, and area are in log-form.
EAP: East Asia and Pacific, SASIA: South Asia, MENA: Middle East and North Africa, SSA: Sub-Saharan Africa, OECD: OECD Countries

The coefficient estimates for trade share range from 1.9 to 6.48 for statistically significant values. The effects of trade share on income for all countries if the instrument is based just on South Asia's to the rest of the world would show an increase of 2.58 percent of income for a one percent increase in trade share. The export-dominated economies of East Asia and Pacific had the lowest significant coefficient for trade openness at 1.9. The coefficient is relatively low due partly to the income losses from the Asian Crisis of 1997-8. The highest coefficient is for Africa (SSA) which is a large reversal from the intra-region results of -0.2. Africa's model of trade with the external world is increasing incomes substantially, while the Africa-only model is reducing incomes.

Table 25. Trade on Income Using Inter-Region Instruments, Panel Data 1980-2005

	(6) LAC	(7) ASEAN	(8) PACRIM	(9) EUR
Trade Openness	5.09***	0.19	-28.24	-1.24
	(1.44)	(1.18)	(93.23)	(0.77)
Population	0.37***	-0.00	-2.20	-0.11*
	(0.12)	(0.09)	(7.24)	(0.07)
Area	0.19**	-0.08	-1.65	-0.16***
	(0.09)	(0.07)	(5.13)	(0.04)
Constant	-2.35	8.18***	69.23	11.24***
	(3.11)	(2.54)	(200.24)	(1.56)
Observations	3039	3039	3039	3039
R-squared		0.02		

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
The dependent variable is the log of GDP per capita. Trade share, population, and area are in log-form.
LAC: Latin America and Caribbean, ASEAN: ASEAN countries, PACRIM: Pacific Rim Countries, EUR: Europe.

After Sub-Saharan Africa, the region whose trade openness has had the largest positive effect on income is the Latin America and Caribbean region. Both population and geographic size have positively contributed to income as well. None of the variations of income due to inter-region trade are well-explained by this model for for ASEAN and Pacific Rim regions. The size and trading scope for Singapore and Japan may have biased the trends displayed for the East Asia and Pacific region, however, this is not clear. Europe as a region fared slightly better. While the coefficient for trade openness is negative, it is not statistically significant. The falling trade barriers within Europe during the observation period may have temporarily produced trade creation to poorer countries.

12. Conclusion

The use of an alternative specification for distance little changes the results of the gravity equation, although it better approximates the distance between economic activities at the national level. The mapped residuals for the IV estimation of trade on income indicates the presence of spatial dependence. Not only is there variation in the effects of trade on income, but the variation is not spatially random. Sub-samples of the entire world's dataset are produced to assess the regional strength of the model and to determine the effects of trade on income by region. The first regional approach estimates the IV regression based solely on intra-region trade, while the second approach condenses countries to regions to produce an inter-region model. The regional gravity estimations confirm the importance of distance, but also highlight that the importance of home and destination country's population and area and being landlocked varies by region and that motivations for trade differ within the region and outside the region. The strength of the geography instrument is largely dependant on the sample of countries used. While a better estimate of the constructed trade share is difficult to obtain with a sub-sample of countries, such a procedure highlights to variance within the data—worse estimates are possible. There are great benefits, especially for the gravity model to sub-sampling since not all countries and regions are equally dependent on trade with neighbors near or far or at all. Regional sub-sampling provides a method to test the robustness of the fitted values of trade that are critical to determine the effects of trade on income without endogeneity and to acknowledge the differing effects of trade on income for different regions. Estimates of trade on income, therefore should be regionally-focused and include regionally appropriate variables such as human capital and foreign direct investment in East Asia, disease prevalence and political stability in Africa, and political and institutional stability in Latin America. Geographic variables provide much greater amounts of information about trade and income even after controlling for size.

Appendix 1. Glossary and Terminology

Agglomeration complementarity - always exists when intermediate goods are costly to transport, because firms then have an incentive to locate their production of these goods near to their assembly operations.

Arm’s length transaction – licensing a foreign firm to produce and distribute instead of establishing their own affiliate.

Competition effects – productivity gain to host country due to increased market pressure on host country firms due to presence of foreign firms.

Composition effect—a higher proportion of foreign firms in a sector is likely to raise productivity in that sector.

Direct Investment – see Foreign Direct Investment

Ergodic (theory) – statistical and quantitative behavior of measurable group and semigroup actions in measurable spaces. Ergodicity is also called stationarity. Non ergodic – (events) that are random, do not follow any prescribed pattern.

Folk Theorem of Spatial Economics: Increasing returns to scale are essential to explaining the economic distribution of activities.

Foreign Direct Investment (FDI) – investment in capital for a controlling stake of a foreign firm. Composed of greenfield investment and mergers and acquisitions. Not to be confused with portfolio investment.

Fragmentation occurs when there are “too many firms producing below an optimal size producing too diverse an array of output, which contributes to lower productivity in both foreign- and domestically owned firms.”

Fragmentation – the location of knowledge-based assets may be fragmented from production. Any incremental of supplying services of the asset to a single plant versus to a single domestic plant is small. The ease of supplying services to a foreign plant.

Greenfield investment – one component of FDI, new investment of capital.

Horizontal clustering—one country becomes to the production and assembly centre for all nearby countries. It is a multi-market access motive. Vertical clustering is a single industry for consumption in another, not necessarily nearby, country.

Jointness – the services of knowledge-based assets are (at least partially) joint ("public") inputs into multiple production facilities. The added cost of a second plant is small compared to the cost of establishing a firm with a local plant.

Linkages – may be backwards or forwards, referring to the increases in demand for production from upstream or downstream industries in the host country or even the home country. These are a captured spillover benefit.

Marshallian Externalities – positive spillovers dues to the secrets of the trade being in the air. Positive spillovers that results from agglomeration due a growing numbers of agents want to congregate to benefit from a larger diversity of activities and a increasing specialization. 'secrets of the industry are in the air' (Fujita and Thisse p 98). In contrast to the Jacobian diversification hypothesis, it argues that diversified production structures favor regional innovativeness... The diversification thesis asserts that knowledge spills over between firms in different industries, causing diversified production structures to be more innovative.

Mergers and Acquisitions (M&A) – the largest component of FDI, implies a change of ownership, but 10% is considered the ownership threshold.

Multinational enterprises or firms (MNEs), Transnational Corporations (TNCs), affiliate production

Nuisance dependency - the spatial dependence between omitted variables that shows up in the error terms.

Source-of-components - complementarity exists only in the presence of transport costs for final goods. It operates for an intermediate range of transport costs for these goods. When the elasticity of substitution between different production activities is not too high, the proportional savings that can be generated by reducing the cost of one activity is greater when the cost of the activity is lower. Then, for an intermediate range of transport costs, it will be profitable to move assembly operations to the low-wage country only if intermediate goods also are produced at low cost.

Spatial Competition – when firms compete against only a limited number of firms in spite of the total number of firms in an economy: competition is local and limited. When production is characterized by increasing returns, demand is spatially dispersed, the economy accommodates only a finite number of firms, which are imperfect competitors since they derive monopoly power from their geographic isolation Developed by Hotelling (1929) and Kaldor (1935).

Spatial Dependence
Substantive spatial dependence - spatial dependence may be displayed through dependent variables. For example, the spread of new technology over a geographic space.

Spillovers
Demonstration effects – productivity transfer to host country via foreign firms demonstrating advanced production methods and technologies.

Tobler's first law of geography: everything is related to everything else, but near things are more related than distant things.

Unit-cost complementarity - arises when a firm locates one production activity in a low-wage country and thereby achieves a lower unit cost. With a lower cost, the firm will wish to produce a greater volume of output and so will have greater incentive to shift other production activities to the low-wage venue (Grossman et al. (2006)

Appendix 2. Supplementary Tables

Table A1. Spatial Regressions, Lag and Error Models 1999-2005

	(Lag)	(Error)
Distance	-0.55***	-0.28
	(0.13)	(0.17)
GDP	1.75***	1.64***
	(0.30)	(0.29)
Population	-0.19*	-0.14
	(0.10)	(0.09)
Skilled Labor	0.02	0.08
	(0.13)	(0.12)
Capital Stock	0.80***	0.70**
	(0.28)	(0.27)
Corruption	0.59***	0.70***
	(0.21)	(0.20)
Market Potential	-0.08	0.36
	(0.29)	(0.32)
W*DIA	-0.34*	-0.20
	(0.18)	(0.20)
Constant	-15.66**	-14.66**
	(6.96)	(7.17)
Rho/Lambda	0.86	(0.96)
	(0.12)	(0.04)
-Log Likelihood	386.92	379.36
Observations	308	308

Direct Investment Abroad on Historical Cost Basis (log) is the dependent variable
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table A2. Model Direct Investment, All Industries, 1999-2005

	(1)OLS	(2)OLS	(3)OLS	(4)FE	(5)RE	(6)SAR
Distance	-0.36**	-0.20	0.53**	0.00	-0.63	0.56**
	(0.18)	(0.19)	(0.27)	(0.00)	(0.43)	(0.25)
GDP	1.63***	1.28***	1.71***	1.51**	1.03***	1.83***
	(0.22)	(0.24)	(0.26)	(0.65)	(0.27)	(0.29)
Population	-0.21*	-0.16	-0.11	-3.99***	-0.38*	-0.13
	(0.11)	(0.11)	(0.11)	(1.40)	(0.23)	(0.11)
Capital Stock	0.64***	0.33	0.80***	0.08	-0.06	0.89***
	(0.21)	(0.22)	(0.26)	(0.23)	(0.19)	(0.27)
Unskilled Labor	-0.03	-0.04	0.18	0.00	-0.24	0.06
	(0.24)	(0.25)	(0.26)	(0.00)	(0.60)	(0.23)
Skilled Labor	-0.62	-0.82	1.00	0.00	-1.55	0.66
	(1.26)	(1.33)	(1.33)	(0.00)	(2.64)	(1.27)
Corruption	0.53**	0.62***	0.78***	0.28	0.35	0.80***
	(0.22)	(0.22)	(0.23)	(0.24)	(0.24)	(0.23)
W*Market Potential	-0.08	0.22	0.64**	-0.32	-0.16	1.11***
	(0.25)	(0.25)	(0.28)	(0.34)	(0.31)	(0.28)
W*Direct Investment	1.86***	0.68	2.06**	0.00	0.30	1.00
	(0.68)	(0.74)	(0.82)	(0.00)	(2.45)	(0.86)
W*Capital Stock	-2.11***	-2.04***	-4.42***	0.00	-0.86	-3.38***
	(0.64)	(0.63)	(0.84)	(0.00)	(2.56)	(0.90)
W*Unskilled Labor		0.76***	0.18	0.92***	0.75***	-0.11
		(0.23)	(0.26)	(0.22)	(0.19)	(0.24)
W*Skilled Labor			1.93***	-0.88	-0.85	1.81***
			(0.46)	(1.15)	(0.64)	(0.43)
ρ (rho)						0.84
						(0.14)
Constant	-6.04	-8.70*	-38.32***	6.67	10.97	-48.99***
	(4.78)	(4.83)	(8.70)	(9.74)	(8.93)	(8.58)
Observations	308	308	308	308	308	308
R-squared/ Wald	0.70	0.71	0.73	0.44		37.74
-Log Likelihood						367.24
Number of Countries				44	44	

Direct Investment Abroad on Historical Cost Basis (log) is the dependent variable
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table A3. KK Model Direct Investment, All Industries, 1999-2005

	(1) OLS	(2) FE	(3) SAR
Distance	0.53**	0.00	0.56**
	(0.27)	(0.00)	(0.25)
GDP	1.71***	1.51**	1.83***
	(0.26)	(0.65)	(0.29)
Population	-0.11	-3.99***	-0.13
	(0.11)	(1.40)	(0.11)
Capital Stock	0.80***	0.08	0.89***
	(0.26)	(0.23)	(0.27)
Unskilled Labor	1.00	0.00	0.66
	(1.33)	(0.00)	(1.27)
Skilled Labor	0.18	0.00	0.06
	(0.26)	(0.00)	(0.23)
Corruption	0.78***	0.28	0.80***
	(0.23)	(0.24)	(0.23)
W*Market Potential	1.93***	-0.88	1.81***
	(0.46)	(1.15)	(0.43)
W*Direct Investment	0.18	0.92***	-0.11
	(0.26)	(0.22)	(0.24)
W*Capital Stock	0.64**	-0.32	1.11***
	(0.28)	(0.34)	(0.28)
W*Unskilled Labor	-4.42***	0.00	-3.38***
	(0.84)	(0.00)	(0.90)
W*Skilled Labor	2.06**	0.00	1.00
	(0.82)	(0.00)	(0.86)
Constant	-38.32***	6.67	-48.99***
	(8.70)	(9.74)	(8.58)
ρ (rho)			0.84
			(0.14)
Observations	308	308	308
R-squared / Wald χ^2	0.73	0.44	37.74
-Log Likelihood			367.24
Number of Countries		44	

Direct Investment Abroad on Historical Cost Basis (log) is the dependent variable
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix 3. Data Descriptions

Variable	Description
year	Year
country	Country
ccode	Country Code
x	Exports of goods and services (constant 2000 US$)
m	Imports of goods and services (constant 2000 US$)
gdp	GDP (constant 2000 US$)
gps	School enrollment, primary (% gross)
gss	School enrollment, secondary (% gross)
pd	Primary education, duration (years)
pop	Population (in thousands)
gdpgr	Gross Domestic Product Annual Growth Rate
nomgdp	GDP (Country1) in Current USD
lpop	Log, population
trade	Sum Exports and Imports
open	Trade (X+M)/GDP
gdpm	GDP (constant 2000 US$) in Millions
area	Surface in kilometers-squared
landarea	Land Area in KM-Squared
larea	log of surface area km-sq
gdppc	GDP per capita
eap	East Asia and Pacific Dummy, Developing Countries
sasia	South Asia, Developing Countries
mena	Middle East and North Africa, Developing Countries
ssa	Sub-Saharan Africa
oecd	OECD Countries
lac	Latin America & Caribbean, Developing Countries
asean	ASEAN: Association of Southeast Asian Nations
pacrim	Pacific Rim Countries
eur	Europe
xgdp	Exports as share of GDP
mgdp	Imports as share of GDP

Variable	Description
ls	Percentage Secondary School Attained in Population, Barro-Lee
lsf	Female, Percentage Secondary School Attained in Population, Barro-Lee
lsm	Male, Percentage Secondary School Attained in Population, Barro-Lee
syr	Average Secondary Schooling Years in Population, Barro-Lee
syrf	Female, Average Secondary School Years in Population, Barro-Lee
syrm	Male, Average Secondary School Years in Population, Barro-Lee
ltrdngdp	Log of Trade/Nominal GDP
ess1	Country-Sum of Exponential of Fitted ltrdngdp (Trade/GDP) without FDI
ess1fdi	Country-Sum of Exponential of Fitted ltrdngdp (Trade/GDP) with IFDI
lgdpgr	Log GDP growth rate
netfdi	Net FDI in current USD
ifdi	Inward FDI as percent of GDP
ofdi	Outward FDI as percent of GDP
i1lag	1 year lag - Inward FDI pct of GDP
o1lag	1 year lag - Outward FDI pct of GDP
i5lag	5 year lag - Inward FDI pct of GDP
o5lag	5 year lag - Outward FDI pct of GDP
lifdi	Log Inward FDI
lofdi	Log Outward FDI
li1lag	Log 1 year lag - Inward FDI pct of GDP
lo1lag	Log 1 year lag - Outward FDI pct of GDP
li5lag	Log 5 year lag - Inward FDI pct of GDP
lo5lag	Log 5 year lag - Outward FDI pct of GDP

Variable	Description
code1	ISO 3166 2-letter Country Codes
cnum	Country Number
corruption	Transparency Intl Corruption Perception Index
lcorr	Ln of Corruption
esumpanel2	Country-Sum of Exponential of Fitted ltrdngdp (Trade/GDP) from Panel data

Appendix 4. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
year	5434	1992.5	7.50069	1980	2005
x	3413	7.77E+10	4.79E+11	6870679	9.71E+12
m	3432	7.75E+10	4.79E+11	3.02E+07	9.75E+12
gdp	4530	3.13E+11	2.11E+12	2.55E+07	3.64E+13
gps	1278	99.26304	18.76511	18.96227	162.7639
gss	1197	69.58111	32.75143	5.191315	178.3826
pd	1794	5.71126	0.983532	3	10
pop	5329	78858.14	480511.4	20	6437784
gdpgr	4673	4.525585	3.650842	-41.3	46.5
nomgdp	4746	499172.6	3307537	46.3	4.44E+07
lpop	5329	8.503641	2.355322	2.995732	15.6777
trade	3401	1.56E+11	9.60E+11	3.82E+07	1.95E+13
open	3384	0.78391	0.498237	0.089216	4.97106
gdpm	4530	312982.1	2106688	25.53152	3.64E+07
area	5434	1716417	9765942	28	1.34E+08
landarea	5434	1667173	9475867	28	1.30E+08
larea	5434	11.24997	2.953244	3.332205	18.71335
gdpt	4530	3.13E+08	2.11E+09	25531.53	3.64E+10
gdppc	4496	4747.534	7332.85	36.86744	49948.02
lgdppc	4496	7.328824	1.602114	3.607329	10.81874
eap	5044	0.113402	0.317115	0	1
sasia	5044	0.041237	0.198858	0	1
mena	5044	0.072165	0.258787	0	1
ssa	5044	0.237113	0.425355	0	1
oecd	5044	0.123711	0.329285	0	1
lac	5044	0.180412	0.384569	0	1
asean	5044	0.051546	0.221131	0	1
pacrim	5122	0.213198	0.409606	0	1
eur	5434	0.186603	0.389628	0	1
xgdp	3396	0.358641	0.249808	0.0397	2.160604
mgdp	3415	0.425044	0.27807	0.033357	2.810456
ls	2663	26.4386	15.08454	1.4	62.5
lsf	2663	24.57041	15.53074	0.8	60.1
lsm	2663	28.33121	15.33707	2	65
syr	2663	1.858908	1.259045	0.088	5.048
syrf	2663	1.700221	1.2527	0.049	5.074
syrm	2663	2.02132	1.298347	0.13	5.312
lsyr	2663	0.333337	0.841448	-2.43042	1.618992
lsyrm	2663	0.458084	0.76711	-2.04022	1.669968
lsyrf	2663	0.147232	1.01267	-3.01594	1.624129
lls	2663	3.056356	0.734835	0.336472	4.135167

Variable	Obs	Mean	Std. Dev.	Min	Max
llsf	2663	2.909104	0.87556	-0.22314	4.09601
llsm	2663	3.148702	0.690981	0.693147	4.174387
ltrdngdp	2184	-8.97492	3.272339	-17.7094	-0.82005
ess1	5434	3.144898	2.652117	0	17.09617
ess1fdi	5434	2.140904	2.398732	0	18.94377
lgdpgr	4428	1.400996	0.692961	-2.30259	3.839452
netfdi	3671	2.48E+08	1.05E+10	-1.93E+11	1.81E+11
ifdi	3913	3.309383	14.34754	-82.8921	523.3765
ofdi	3584	0.933651	13.29852	-89.4532	569.454
i1lag	3747	3.198114	13.78361	-82.8921	523.3765
o1lag	3462	0.809261	12.34673	-89.4532	569.454
i5lag	3065	2.609387	9.166996	-82.8921	348.1892
o5lag	2893	0.384135	2.532744	-89.4532	35.17085
lifdi	3620	0.115738	1.820949	-11.8811	6.260301
lofdi	1812	-1.32209	2.051993	-9.20039	6.344678
li1lag	3463	0.080361	1.830563	-11.8811	6.260301
lo1lag	1729	-1.37403	2.042677	-9.20039	6.344678
li5lag	2809	-0.08121	1.859686	-11.8811	5.852746
lo5lag	1362	-1.48199	1.979076	-9.20039	3.560218
code1	0				
cnum	5278	424.4729	254.5175	4	894
corruption	964	4.759585	2.411245	0.4	10
lcorr	964	1.429977	0.518202	-0.91629	2.302585
esumpanel2	4524	9.070208	12.29518	0	91.04649

Appendix 5. Country Groups

The major source for these country groups is the World Bank's World Development Indicators (WDI). WDI exclude developed countries, such as Japan from East Asia and Pacific. The list include the category name and code in parentheses, followed by the list of countries. The lists exclude countries for which there is insufficient data, such as Kiribati, Palau, and North Korea.

ASEAN Countries	**(asean)**
Brunei Darussalam	Myanmar
Cambodia	Philippines
Indonesia	Singapore
Lao PDR	Thailand
Malaysia	Vietnam

Note: Singapore, but not Japan

East Asia and Pacific, developing	**(eap)**
Brunei Darussalam	Myanmar
Cambodia	Papua New Guinea
China	Philippines
Fiji	Samoa
Indonesia	Solomon Islands
Korea, Rep.	Thailand
Lao PDR	Tonga
Malaysia	Vanuatu
Mongolia	Vietnam

Note: Kiribati, Palau, Taiwan, and Timor-Leste are excluded due to insufficient data.
Japan and Singapore were excluded by the WB because they are considered developed. North Korea (People's Republic of) is also excluded, although insufficient data exist anyway.

Europe	**(eur)**
Austria	Lithuania
Belarus	Luxembourg
Belgium	Macedonia, FYR
Bosnia and Herzegovina	Malta
Bulgaria	Moldova
Croatia	Netherlands
Cyprus	Norway
Czech Republic	Poland
Denmark	Portugal
Estonia	Romania
Faroe Islands	Russian Federation
Finland	Serbia and Montenegro
France	Slovak Republic
Germany	Slovenia
Greece	Spain
Hungary	Sweden
Iceland	Switzerland
Ireland	Ukraine
Italy	United Kingdom
Latvia	

Latin American and Caribbean, developing	**(lac)**
Argentina	Guiana, French
Belize	Haiti
Bolivia	Honduras
Brazil	Jamaica
Chile	Mexico
Colombia	Nicaragua
Costa Rica	Panama
Cuba	Paraguay
Dominica	Peru
Dominican Republic	St. Vincent and the Grenadines
Ecuador	Suriname
El Salvador	Trinidad & Tobago
Greece	Uruguay
Guatemala	Venezuela

Middle East and North Africa, developing	**(mena)**
Algeria	Libya
Djibouti	Morocco
Egypt	Oman
Iran, Islamic Republic of	Qatar
Iraq	Syria
Jordan	Tunisia
Lebanon	Yemen, Republic of

Note: Israel is not included, however trade between Israel and countries in MENA is 0 for political reasons.

OECD Countries (oecd)	
Australia Austria	Korea, Republic of
Belgium	Luxembourg
Canada	Netherlands
Denmark	New Zealand
Finland	Norway
France	Portugal
Germany	Spain
Greece	Sweden
Iceland	Switzerland
Ireland	United Kingdom
Italy	United States
Japan	

Pacific Rim Countries	**(pacrim)**
Australia	Mexico
Brunei Darussalam	New Zealand
Canada	Nicaragua
Chile	Panama
China	Papua New Guinea
Colombia	Peru
Costa Rica	Philippines
Ecuador	Russian Federation
El Salvador	Samoa
Fiji	Singapore
Guatemala	Solomon Islands
Honduras	Thailand
Hong Kong	Tonga
Indonesia	United States

Continued

Pacific Rim Countries	**(pacrim)**
Japan	Vanuatu
Korea, Republic of	Vietnam
Malaysia	

Note: No Cambodia, but there is Japan

South Asia (sasia)	
Afghanistan	Nepal
Bangladesh	Pakistan
India	Sri Lanka
Maldives	

Sub-Saharan Africa	**(ssa)**
Angola	Madagascar
Benin	Malawi
Burkina Faso	Mali
Burundi	Mauritania
Cameroon	Mauritius
Cape Verde	Mozambique
Central African Republic	Niger
Chad	Nigeria
Comoros	Rwanda
Congo, Democratic Rep.	Sao Tome e Principle
Congo, Republic of	Senegal
Côte d'Ivoire	Seychelles
Equatorial Guinea	Sierra Leone
Ethiopia	Somalia
Gabon	South Africa
Gambia, The	Sudan
Ghana	Tanzania
Guinea	Togo
Guinea-Bissau	Uganda
Kenya	Zambia
Liberia	Zimbabwe

Insufficient data for Eritrea.

Appendix 6. Gravity Model Without and With Population Controls, 1980-2005

Stage 1. Gravity Model Without and With Population Controls, 1980-2005, Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)
$Distance_{ij}$	-1.36***	-1.34***	-1.37***	-1.35***	-1.33***	-1.36***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Pop_i	-0.68***	-0.48***	-0.57***	-0.65***	-0.46***	-0.55***
	(0.04)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)
Pop_j	1.15***	1.14***	1.15***	1.18***	1.16***	1.17***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$Area_j$	-0.36***	-0.34***	-0.34***	-0.37***	-0.36***	-0.36***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Inward FDI		-0.03			-0.02	
		(0.05)			(0.05)	
Lagged FDI			-0.06			-0.06
			(0.06)			(0.06)
Constant	3.23***	1.31***	2.30***	2.89***	1.00**	2.03***
	(0.40)	(0.44)	(0.43)	(0.41)	(0.45)	(0.44)
Observations	186,534	159,625	171,557	181,076	155,794	167,442
Number of Countries	165	150	151	162	148	149
R-squared	0.36	0.37	0.37	0.35	0.36	0.36

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependant variable is nominal Trade (Exports+Imports)/nominal GDP, in log form. Populations, areas, and FDI are all in form log.

Column (4-6) use population controls employed by Frankel and Romer (1999) and (1-3) use the full panel of countries. Columns (4-6) omit any small countries, countries with populations less than 100,000 due to possible biases.

Appendix 7. Trade on Income with Corruption

OLS and IV for Trade on Income with Corruption

	(1) OLS	(2) IV	(3) IV-FDI
Trade Openness	-0.29***	0.96***	1.50***
	(0.07)	(0.18)	(0.37)
Popi	0.07***	0.06*	0.06
	(0.03)	(0.03)	(0.04)
Areai	-0.10***	0.10**	0.19**
	(0.02)	(0.04)	(0.08)
Male Schooling	0.67***	0.56***	0.51***
	(0.08)	(0.08)	(0.09)
Corruption	2.07***	2.03***	2.02***
	(0.10)	(0.12)	(0.13)
Constant	3.79***	0.81	-0.46
	(0.34)	(0.51)	(1.00)
Observations	629	629	629
R-squared	0.76	0.67	0.57

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix 8. Distance Correlations

Distance Measures

ldist	Log of Simple Distance (most populated cities, km)
ldistcap	Log of simple distance between capitals (capitals, km)
ldistw	Log of weighted distance (pop-wt, km)
ldistwces	Log of CES weighted distance (pop-wt, km)

Correlations between (log of) distance measures
(obs=167334)

	ldist	ldistcap	ldistw	ldistwces
ldist	1.0000			
ldistcap	0.9980	1.0000		
ldistw	0.9944	0.9952	1.0000	
ldistwces	0.9957	0.9963	0.9983	1.0000

Appendix 9. Author Index

Appendix 10. Subject Index

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