The Growth of FDI Relative to Trade:
Measurement, Determinants, and Consequences of International Trade Flows in Intermediates

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Abstract

One of the most celebrated stylized facts in international economics over the past two decades is the growth of foreign direct investment (FDI) relative to trade and to world output. We explain the growth of FDI relative to trade using another highly celebrated fact – the growth in outsourcing of intermediate inputs. Using the United Nations’ Classification by Broad Economic Categories, we construct the first comprehensive panel data set of final and intermediate goods bilateral trade flows for 160 countries from 1990 to 2000. Motivated by a new general-equilibrium knowledge-and-physical-capital model with intermediates, we show that falling intermediates trade costs and subsequent outsourcing during this period explains a significant amount of the growth of FDI to trade, even after accounting for changes in investment and trade costs and in economic size and similarity. In deriving these results, we motivate a theoretical rationale for estimating gravity equations of bilateral final goods trade, intermediate goods trade, and FDI flows and for the observed higher value added per worker of multinational firms relative to national exporters.

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Specifically, empirical work based upon general equilibrium models has focused instead upon explaining the cross-sectional patterns of levels of bilateral foreign affiliate sales (FAS), FDI, or the ratio of FAS to trade in a particular year. For instance, Carr, Markusen, and Maskus (2001) and Blonigen, Davies, Waddel, and Naughton (2007), while employing panel data sets, focused only on explaining the patterns of bilateral FAS and FDI levels, respectively, but not exports relative to FAS (or FDI). Brainard (1997) focused upon cross-industry and cross-country-pair economic characteristics to explain cross-country-pair exports relative to FAS for the United States with partners; however, she used only a cross-section for the year 1989, and so could not explain growth of the ratio. Similarly, Helpman, Melitz, and Yeaple (2004), while also explaining exports relative to FAS, use a cross-section of data for the year 1994. Moreover, as the latter study notes, the use of cross-country variation in RHS variables required them to relax the assumption of “symmetric countries” in their theoretical model; however, their focus was instead upon explaining cross-sectional firm-level selection into exporting versus FAS. By contrast, as detailed later in our paper, our theoretical model allows asymmetric countries and our empirical work (using country-pair fixed effects) focuses upon the time-series variation of bilateral FDI relative to bilateral trade to explain specifically the growth of (aggregate) FDI to trade.

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“[It is well known that] the growth of multinational enterprise (MNE) activity in the form of foreign direct investment (FDI) has grown at a faster rate than most other international transactions, particularly trade flows between countries.” (Blonigen, 2005, p. 383)

“I [think that] we have spent way too much time on differentiated final goods, and neglected trade in intermediates . . . . Ethier’s (AER, 1982) intermediates-inputs approach seems empirically very relevant, and formal econometric work would be very welcome.” (James Markusen, interview in Leamer, 2001, p. 382)

I. Introduction

As Markusen (2002), Barba Navaretti and Venables (2004), Blonigen (2005), and Helpman (2006) all note in their surveys of multinational enterprises (MNEs), one of the most celebrated stylized facts in international economics of the past two decades has been that foreign direct investment (FDI) has grown considerably faster than trade since 1990. Many of the studies cite increases in the ratio of FDI to trade of more than 100 percent over a ten-year period. Despite all of their papers’ introductions making this claim, there have been no systematic empirical studies actually explaining the recent enormous growth of FDI relative to trade – much less one based upon a formal theoretical economic model.

This paper attempts to explain this fact – empirically and theoretically – drawing upon the other highly celebrated stylized fact of the last two decades: the growth of international outsourcing of intermediate inputs. However, because of a well-known absence of any comprehensive data set decomposing world trade flows by end-use – that is, final versus intermediate goods – economists have little systematic knowledge about the actual pattern of flows of final versus intermediate goods around the world. Consequently, we must first pursue the suggestion in Markusen’s quote above to investigate empirically determinants of intermediate goods trade.

In explaining the growth of FDI relative to trade and the role of intermediates trade, we organize our study around three potential contributions. First, economists actually know very little about the measurement of

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As clarified in Amiti and Wei (2004), the dictionary defines “outsourcing” as the “procuring of services or products . . . from an outside supplier or manufacturer” (p. 36). Hence, outsourcing of intermediates can also be carried on domestically (with no international transaction); such outsourcing is allowed in our model also. While popular press accounts of international outsourcing have focused attention on producer services, it is well known that “international outsourcing of material inputs is still far greater than that of services . . . .” (Amiti and Wei, 2004, p. 37). Our study focuses on material (or goods) outsourcing.

In our study, we have compiled the first systematic decomposition of annual bilateral aggregate trade flows among 160 countries into bilateral final goods trade flows and intermediate goods trade flows for 11 consecutive years from 1990 through 2000 using the United Nations’ Classification by Broad Economic Categories (2003), which distinguishes final (consumer and capital) goods from intermediate goods, and the UN’s COMTRADE data, by aggregating 5-digit Standard International trade Classification trade flows into final and intermediate goods trade flows. By decomposing systematically bilateral final and intermediate goods trade flows (and collecting bilateral FDI flows) between and among developed and developing economies, we uncover two novel stylized “facts.” First, contrary to popular hype, the vast bulk of intermediates trade is among developed countries, not between developed and developing countries. This is consistent with Jabbour (2007), which showed in an extensive empirical analysis of 4305 French firms (using non-UN survey data) that the vast bulk of these firms import their intermediate inputs from other developed economies through arm’s-length transactions. Consequently, most intermediates trade is intra-industry (and likely “Ethier-type” intermediates trade). Second, the vast bulk of the growth of FDI relative to trade also has been among developed economies. These two stylized facts are central to our analysis.

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3 We also confirm the widely known “fact” that the bulk of FDI is among developed countries; however, a lesser known fact is that the bulk of growth of FDI relative to trade is also among developed economies. Moreover, we show that between 1990-2000 intermediates’ share of trade has grown between developed and developing countries and among developing countries, in contrast to the conclusion in Hummels, Ishii and Yi (2001) that this share has been “steadily declining since 1970.”
Second, because of the previous absence of a comprehensive data set on intermediates and final goods trade flows, econometric analysis of the determinants of outsourcing intermediates trade volumes/values is virtually nonexistent, as our quote from Markusen (2001) suggests.¹ Egger and Egger (2005) provide one of only two empirical (gravity) analyses of a narrow aspect of outsourcing trade flows – bilateral “processing” trade among 12 European Union economies by national and multinational enterprises. The other empirical study is Baldone, Sdogati, and Tajoli (2002).⁵ Aside from these two empirical analyses, the absence of systematic intermediates versus final goods trade data has confined many researchers of outsourcing to employing numerical simulations to study final and intermediates trade volumes (cf., Baier and Bergstrand, 2000, and Yi, 2003). Moreover, the absence of bilateral trade data decomposed by final versus intermediate goods has resulted in no motivation for developing a theoretical foundation for (separate) gravity equations for final goods bilateral trade versus intermediates bilateral trade – much less one that accounts for multinational enterprises, FDI, and potential consequences of outsourcing for these factors. Consequently, as Markusen’s quote suggests, it is now time to pursue “formal econometric work” on the determinants of intermediates trade flows – with Ethier-type intermediates trade in mind.

Consequently, in the spirit of the “Knowledge-Capital” model in Markusen (2002) and the “Knowledge-and-Physical-Capital” model in Bergstrand and Egger (2007), we develop a 3-factor, 3-country, 3-good general equilibrium model of multinational and national firms with intermediates. A numerical version of the general equilibrium (GE) model motivates a theoretical rationale for estimating gravity equations of bilateral intermediate goods trade – and in a manner consistent with estimating gravity equations of bilateral final goods trade and FDI flows. Interestingly, the theoretical gravity equations for all three types of flows are not exactly the same, and we use the GE model to explain the slightly different theoretically-motivated gravity specifications.⁶ We find that economic-size-related Ethier-type trade explains empirically the vast bulk of the variation in bilateral intermediates international trade flows. Moreover, we provide empirical evidence that bilateral final goods trade flows, intermediates trade flows, and FDI flows are all driven by a “common process.” This conclusion is important

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¹ Most of the empirical analyses of the consequences of outsourcing have had to focus instead on multilateral issues, such as relative price effects (that is, the effects on the “wage skill premium”), and for only a few specific countries.

⁵ “Processing trade” refers to intermediates goods imports (exports) of countries that are “processed” (or value is added) in a special economic “zone” without tariffs imposed, and then are re-exported to the original country with tariff exemption again. This is economically a very small portion of these countries’ intermediates trade. Another empirical analysis (non-gravity-equation) of processing trade is Görg (2000).

⁶ The introduction of intermediate goods introduces a complexity not present in Bergstrand and Egger (2007), which did not distinguish between final and intermediates goods. Markusen (2002, Ch. 9) introduced a traded intermediate input; however, he assumed (for some “exogenous reason”) it could be produced in only one country (which precluded two-way trade).
because it implies that previous gravity equations of bilateral trade (FDI) flows including on the RHS bilateral FDI (trade) flows are seriously mis-specified, likely suffering from endogeneity bias.

Third, after establishing theoretically and empirically determinants of each of the three types of flows, we are in a position to evaluate the role of Ethier-type intermediate goods trade for explaining the growth of FDI relative to final goods trade – which has been concentrated empirically among developed economies7 – as well as a potential explanation for the observed higher value added per worker of horizontal MNEs (HMNEs) compared with national exporters (NEs). Since our theoretical model can allow or disallow intermediates production and trade, we can use our model to show that the introduction of intermediates can have a nontrivial effect on cross-country-pair levels of FDI relative to trade. Numerous recent econometric analyses (motivated theoretically by an Ethier-type intermediates framework) provide strong evidence that plants that import a larger share of intermediates are more productive (on average about 14 percent more productive), with two-thirds of the productivity increase attributable to “increased variety” of the Ethier (1982) type, cf., Halpern et al. (2006) and Kasahara and Rodrigue (2008).

However, HMNEs differ from NEs in that HMNEs (NEs) have multiple (single) plants. Because developed economies have more horizontal than vertical multinational activity, multi-plant HMNEs potentially benefit more from increased outsourcing of intermediates (attribute to falling intermediates trade costs over time) relative to single-plant exporting firms, implying a rise in multinational activity (and FDI) relative to trade among developed economies.8 This rationale can also provide an economic explanation for higher value added per worker (lower firm-wide marginal production costs) among HMNEs relative to NEs in the recent MNE literature; multi-plant HMNEs’ productivity benefits more from outsourcing than does single-plant NEs’ productivity as long as intermediates trade follows a gravity relationship because HMNEs can economize on intermediates transport costs (relative to NEs) as a result of their “geographically-fragmented” plant structure. Because the model is calibrated numerically, we can even predict quantitatively the general equilibrium comparative-static increase in the ratio of bilateral FDI to bilateral final goods trade for a representative pair of developed countries of introducing intermediates “outsourcing.”

However, since our theory suggests that all three flows are determined by a common process, we cannot simply include intermediates trade flows on the RHS in a gravity equation explaining empirically FDI flows relative to final goods trade flows over time. Instead, we apply an instrumental variables estimation procedure to explain

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7 Although outward FDI growth has been higher from developed to developing economies than among developed economies, trade growth between developed and developing economies has grown almost as much as FDI, so that the ratio of FDI to trade has not grown nearly as much between developed and developing economies as among developed economies.

8 See Markusen (2002), Markusen and Maskus (2002), and Blonigen, Davies and Head (2003) for empirical support on U.S. MNE activity explained predominantly by horizontal motives.
empirically the effect of increased international intermediates outsourcing (due to falling intermediates’ trade costs) on the growth of FDI relative to final goods trade. We examine pooled cross-section data to explain the FDI-to-trade relationship in the long run and time-series variation to examine the growth of FDI relative to trade over the 1990s in particular. We find economically and statistically significant evidence that international outsourcing of intermediates explains a substantive part of the increase of FDI relative to final goods trade during the 1990s, even after accounting for changes in investment and trade costs and for changes in economic size and similarity over time.9

The remainder of the paper is as follows. Section II motivates the analysis and discusses the construction of our new data set of annual bilateral final goods and intermediate goods trade flows among 160 countries for the period 1990-2000. Section III presents the theoretical framework. Section IV summarizes the calibration of our theoretical model. Section V provides numerical results using our model suggesting a theoretical rationale for estimating gravity equations for bilateral final goods trade, intermediate goods trade, and FDI flows. Section VI provides the empirical gravity equation results. Section VII discusses the theoretical and empirical results explaining the growth of FDI relative to final goods trade. Section VIII concludes.

II. Decomposing Aggregate Bilateral Trade Flows into Final and Intermediate Goods Trade Flows

Recent books in the popular press such as Thomas Friedman’s *The World is Flat* (2005) and associated newspaper articles on international “outsourcing” (also known as “fragmentation” or “slicing-up-the-value-chain”) of intermediate stages of production suggest that the bulk of outsourcing is due to differences between countries in the cost of labor (relative wage rates). The stories suggest that increased international imports of developed economies from developing economies or increased outward foreign direct investment (FDI) of developing countries to developed countries dominate international trade and FDI flows, respectively, in the past several years. However, it is useful first to look at the data – which suggest a much different story.

Table 1a presents a decomposition of international trade and FDI flows between and among developed and developing economies between 1990 and 2000. The first panel in the upper left corner of Table 1a provides data on the share of world trade flows (where, for empirical purposes, our “world” consists of 160 countries) among two groupings of economies, developed and developing. For empirical purposes, we consider the original 24 members of the Organization for Economic Cooperation and Development (OECD) as the “developed” economies and another 136 economies as the “developing” (or non-OECD) economies; in 1990 (our sample’s beginning year) the OECD had only 24 members. As this panel shows, more than half of world trade flows are among the 24 richest (highest

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9 The latter source of growth of FDI to trade was suggested in Markusen (2002, pp. 83-85), which we address later.
per capita income) economies in the world, which comprise only 1/6 of the number of countries in our sample. Moreover, only 15 percent of OECD imports come from the developing economies – which contrasts sharply with the suggestions of *The World is Flat* and similar newspaper articles.

The panel in the upper right of Table 1a shows that (outward) FDI flows are also concentrated among the developed economies, in similar proportion to trade flows. 58 percent of all outward FDI was among the 24 richest countries in the world. Thus, if multinational firms of OECD economies are investing abroad, the *vast bulk* of their FDI is with similar high per capita income economies, not with the developing world. Only 20 percent of world outward FDI flows are from developed to developing economies. Thus, as has been established in such sources as Markusen (2002) and Barba and Navaretti (2004, *Fact 2*), the bulk of international trade *and* FDI is among a small number of similar, developed economies; Markusen (2002) and others term this “horizontal” FDI.

Yet, data such as presented in the upper panels of Table 1a are quite well known and are readily obtainable. *Much less known* is the information in the bottom two panels of Table 1a. These two panels decompose world trade flows into final goods trade flows and intermediate goods trade flows, using the new data set that we constructed. Before explaining these data, we provide some background. As discussed briefly in the introduction, there has been limited systematic empirical analysis of international outsourcing of intermediates production owing to a dearth of comprehensive data decomposing trade into final and intermediate products.\(^\text{10}\) As Feenstra (1998) notes, there have been only a few selected empirical treatments of outsourcing, which he cites. For instance, even though input-output tables exist for the United States and a few other industrialized economies, the U.S. Input-Output (I-O) tables do not decompose intermediate inputs into imported and domestically-produced intermediates (Feenstra, 1998, p. 38). However, Feenstra and Hanson (1999) combine U.S. industry data with U.S. economy-wide I-O tables to calculate the increased share of imported intermediates in production in the United States. Campa and Goldberg (1997) perform similar calculations for Canada, Japan, the United Kingdom and the United States and show similar trends, except for Japan. Hummels, Rapaport and Yi (1998), Hummels, Ishii and Yi (2001), and Yi (2003) do like computations for ten OECD economies to demonstrate increased outsourcing or – in their framework – increased “vertical specialization.”

However, none of these studies or others has made an attempt to build a comprehensive data set of bilateral trade flows for final and intermediates trade flows, starting with highly disaggregated bilateral trade flow data. Using the United Nations’ (UN’s) COMTRADE data base, we aggregated 5-digit Standard International Trade

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\(^\text{10}\) A more typical decomposition of aggregate trade has been by industry classification rather than by final versus intermediates classification. Also, we note now that our intermediates (or final goods) data includes “intra-firm” intermediates trade, that is, intermediates trade between an MNE and an affiliate abroad; such trade is more accurately termed “offshoring” rather than outsourcing (since the latter is an arm’s-length transaction). As we will address later, the share of intra-firm trade in total trade has been quite constant over time (especially within our sample).
Classification (SITC) bilateral trade flows into (aggregate) bilateral final goods trade flows and bilateral intermediate goods trade flows according to the UN’s *Classification by Broad Economic Categories* (2003), which distinguishes intermediates from final (consumer and capital) goods. The final goods trade flows aggregate 1561 5-digit SITC categories and the intermediate goods trade flows aggregate 1560 different 5-digit SITC categories. Table 2 shows a decomposition into final and intermediates of the 3121 economic categories used to create the two aggregates.

The bottom two panels of Table 1a show the shares of world final goods and intermediate goods trade flows between and among OECD and non-OECD countries. The most notable conclusion is the striking similarity of the pattern of trade flows in final and intermediate goods. For both types of goods, approximately 55-56 percent of world trade flows are among the OECD countries. Moreover, the remaining shares are also nearly identical to those for aggregate goods exports. Furthermore, the share of intermediate goods imports of OECD countries from non-OECD countries is only 12 percent, even smaller than the 17 percent for final goods imports. Thus, final goods – not intermediate goods – dominate developed countries’ imports from the developing world.

Such data suggest that much – if not the majority – of world intermediates trade flows are *intra-industry* trade flows among similar, high per capita income economies – as is the case for the well-documented intra-industry trade in final goods that has been the subject of theoretical and empirical study for the last 30 years, cf., Grubel and Lloyd (1975). This conjecture regarding data is behind Markusen’s quote above suggesting Ethier’s (1982) “intermediates-input approach” as a motivation for much of world trade and “formal econometric work (of intermediates trade) would be very welcome.” To put it simply, just as the bulk of international trade flows are intra-industry in nature and were explained by Helpman and Krugman (1985) using a model of intra-industry trade in final goods – and Markusen (2002) and Barba Navaretti and Venables (2004) showed that the bulk of FDI flows are intra-industry (horizontal) in nature – we show here that the bulk of intermediates outsourcing is intra-industry (Ethier-type) trade in nature. This is consistent with the results in Jabbour (2007) using an empirical analysis of survey data for 4305 French firms. She showed that the vast bulk (63 percent) of these French firms’ intermediate imports were arm’s-length transactions with firms in other developed economies.

Another interesting stylized fact from our data set is that intermediates trade growth among OECD countries (3.96 percent annually) has been slightly less than that of final goods trade growth (4.41 percent annually) from 1990 to 2000. These growth rates are consistent with the data discussed in Hummels, Ishii, and Yi (2001) using the same *Classification by Broad Economic Categories*. However, we note that intermediates trade growth has exceeded final goods trade growth for trade between developed and developing countries and among developing countries between 1990 and 2000, in contrast to their conclusion of a “steadily declining since 1970” intermediates trade share.

Our data set also allows us to decompose the sources of trends of world FDI relative to world trade into that for OECD countries, non-OECD countries, and between OECD and non-OECD countries for the period 1990 to
2000. Even though FDI growth has been fastest from non-OECD to OECD countries, the ratio of FDI growth to trade growth has by far been fastest among OECD countries, as implicit in Table 1b (top panels). For instance, for OECD countries FDI has grown 125 percent faster than trade has grown (8.94 percent annually; 8.94 = 13.15-4.21). By contrast, FDI growth has exceeded trade growth between OECD and non-OECD countries by only 25-40 percent. And FDI growth among non-OECD countries has actually been slower than their trade growth; FDI has fallen relative to trade (9.85 percent annually).

Thus, to explain the predominance of outsourcing of material intermediates and the trend in worldwide FDI relative to trade among OECD countries noted in the introduction, one needs to look in particular at developed countries’ trade and FDI. These stylized facts are the motivation for our analysis. In the remainder of this paper, we provide a theoretical and empirical model to address these stylized facts. The framework will address the main economic determinants of intermediate goods trade – in a manner consistent with explaining final goods trade and FDI flows. Then, we use the framework to explain – theoretically and empirically – the growth in FDI relative to trade among OECD economies.

III. The Theoretical Model

In this section, we develop a theoretical model to motivate estimating gravity equations of bilateral final goods trade, intermediate goods trade, and FDI flows (simultaneously) and to explain the growth of FDI (multinational firms) relative to trade (national firms). In fact, our model can explain in particular a significant portion of the 125 percent increase in FDI relative to trade among OECD countries over the period 1990-2000. In the spirit of Ethier (1982), a key consideration is international trade in intermediate goods among similar developed economies. Since the vast amount of outsourcing and FDI is among developed economies with similar relative factor endowments and consequently similar relative real wage rates, then one could argue that “outsourcing” in general will have not have the impact upon the convergence of relative wage rates internationally that the popular press suggests. Moreover, our analysis will suggest that a vast amount of increased growth in FDI relative to final goods trade among OECD countries is likely consistent with either no change – or possibly a decline – in the return to skilled labor relative to unskilled labor, but a possible rise in the return to physical capital relative to labor.\footnote{We do not argue that vertical FDI and inter-industry trade between developed and developing countries with differing relative factor endowments (such as the United States and China) has not grown; it has (as our Table 1b suggests) and has likely contributed to the rise in income inequality in developed economies. Rather, our goal here is to highlight, and confirm empirically, the overlooked argument that the bulk of outsourcing and of FDI growth relative to trade is more likely due to horizontal (intra-industry) considerations.}

To address the issues of outsourcing and FDI-relative-to-trade growth, we need a model that explains first the relationships between multinational enterprises that investment capital directly in foreign countries, national firms...
that trade either final or intermediate goods, FDI flows, final goods trade flows, and intermediate goods trade flows. To address bilateral flows in a multilateral world, we need 3 countries. The model we develop is a 3-country, 3-factor, 3-good model of MNEs and national enterprises with internationally-immobile skilled and unskilled labor, internationally-mobile physical capital, and final and intermediate goods, in the spirit of Markusen’s “Knowledge-Capital” model. In fact, the “Knowledge-and-Physical-Capital” model developed in Bergstrand and Egger (2007), which is an extension of the “Knowledge-Capital” model of Markusen (2002), is a special case (with no intermediates production) of our model.

As background, the Knowledge-and-Physical-Capital model in Bergstrand and Egger (2007) is a 3-factor, 3-country, 2-good extension of Markusen’s 2x2x2 Knowledge-Capital model with national enterprises (NEs), horizontal multinational enterprises (HMNEs), and vertical multinational enterprises (VMNEs). The demand side in the Knowledge-and-Physical-Capital model is analogous to that in the Knowledge-Capital model. However, the former extends the latter in two significant ways. The first distinction is to use *three* primary factors of production: unskilled labor, skilled labor (or human/knowledge capital), and physical capital. We assume unskilled and skilled labor are immobile internationally, but physical capital is mobile in the sense that MNEs will endogenously choose the optimal allocation of domestic physical capital between home and foreign locations to maximize profits, consistent with the BEA definition of foreign “direct investment positions” using domestic and foreign-affiliate shares of real fixed investment.12 Thus, unlike the Knowledge-Capital model, we actually have *FDI* (as well as FAS).13 The introduction of a third factor – combined with an assumption that headquarters’ fixed setups require home skilled labor (to represent, say, research and development (R&D) costs) while the setup of a plant in any country requires the home country’s physical capital (to represent, say, equipment) – can explain “coexistence” of HMNEs and NEs for two identically-sized developed countries for a wide range of parameter values (which is precluded in the Knowledge-

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12In the typical 2x2x2 model, headquarters use home skilled labor exclusively for setups; home (foreign) plants use home (foreign) skilled labor for setups (cf., Markusen, 2002, p. 80). With only immobile skilled and unskilled labor, the 2-factor models preclude home physical capital being utilized to set up foreign plants. We often refer to the transfer of physical capital by MNEs as capital “mobility.” Consistent with Markusen (2002) and the modern MNE literature, the model is “real”; there are no paper assets. In this regard, we follow the more traditional (pre-1960) literature defining capital mobility in terms movement of physical capital, cf., Mundell (1957, pp. 321-323), Jones (1967), and Helpman and Razin (1983). Moreover, while physical capital can be “utilized” in different countries, “ownership” of any country’s endowment of such capital is immobile; again, we follow Mundell (1957) in this regard: “Capital is here considered a physical, homogeneous factor . . . . It is further assumed that capitalists qua consuming units do not move with their capital, so national taste patterns are unaltered.” In reality, of course, the presence of (paper) “claims” to physical capital allows much easier “transfer” of resources and is one way of measuring FDI. However, the “current-cost” method of measuring FDI is related to the shares of an MNE’s *real* fixed investment in plant and equipment that is allocated to the home country relative to foreign affiliate(s); this effectively measures physical capital mobility, cf., Borga and Yorgason (2002, p. 27). Also, (bilateral) FDI stocks are the accumulation of (bilateral) FDI flows over several periods. Since our model is static, FDI flows and stocks are necessarily identical in the model.

13Markusen (2002, p. 8) notes clearly that the models in his book “are addressed more closely to affiliate output and sales than to investments stocks.”
As in Markusen (2002), internationally-immobile skilled labor still creates firm-specific intangible assets that are costlessly shared internationally by MNEs with their plants. This aspect is maintained.

Moreover, introducing MNE intra-firm trade in intermediates introduces yet another level of complexity far beyond the scope of this paper. However, we will document later that data used in other studies suggest that the share of intra-firm trade in all intermediates trade has been constant (or declining) over the 1990s, the period examined in our study.

\[ \text{Capital model).}^{14} \]

The second distinction of the Knowledge-and-Physical-Capital model is to introduce a “third country.” The presence of the third country helps explain the “complementarity” of bilateral FAS and trade with respect to a country pair’s economic size and similarity and that bilateral FDI empirically tends to be maximized when the home country’s GDP is larger than the host country’s. Hence, the 3-factor, 3-country, 2-good model in Bergstrand and Egger (2007) provides a theoretical foundation for estimating “gravity equations” of bilateral FDI and aggregate trade flows simultaneously. However, the model in Bergstrand and Egger (2007) does not differentiate between final goods trade and intermediate goods trade.

The model in this paper is a more general version of the model in Bergstrand and Egger (2007) by introducing a third good (intermediates) – more accurately, a second production stage – to distinguish final from intermediate goods. Here, we separate national firms that produce and export final goods for consumers from national firms that produce and export intermediate goods that can be purchased by other national firms that produce final goods or horizontal MNEs with headquarters in one country but additional plants in either one or two other countries to serve local markets or vertical MNEs with headquarters in one country but a plant in another country due to different relative factor endowments between the two countries. Hence, a representative intermediates firm in some country \( i \) can sell its output to final goods-producing NEs, HMNEs, or VMNEs based in its own country, in another country \( j \), or in the Rest-of-World (ROW). All intermediate goods purchases are “arm’s-length” transactions between legally distinct entities; hence, they conform to the conventional definition of “outsourcing.” Introducing domestic and international outsourcing of intermediates to the model of Bergstrand and Egger (2007) enhances dramatically the complexity of the model.\(^{15}\)

A. Consumers

Consumers are assumed to have a Cobb-Douglas utility function between final differentiated goods \( (X) \) and homogeneous goods \( (Y) \). Consumers’ tastes for final differentiated products (e.g., manufactures) are assumed to be of the Dixit-Stiglitz constant elasticity of substitution (CES) type, as typical in trade. We let \( V_i \) denote the utility of the representative consumer in country \( i \). Let \( \eta \) be the Cobb-Douglas parameter reflecting the relative importance of manufactures in utility and \( \epsilon \) be the parameter determining the constant elasticity of substitution, \( \sigma \), among these

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\(^{14}\)As in Markusen (2002), internationally-immobile skilled labor still creates firm-specific intangible assets that are costlessly shared internationally by MNEs with their plants. This aspect is maintained.

\(^{15}\)Moreover, introducing MNE intra-firm trade in intermediates introduces yet another level of complexity far beyond the scope of this paper. However, we will document later that data used in other studies suggest that the share of intra-firm trade in all intermediates trade has been constant (or declining) over the 1990s, the period examined in our study.
manufactured products ($\sigma = 1 - \epsilon, \epsilon < 0$). Manufactures can be produced by three different firm types: national firms ($n$), horizontal multinational firms ($h$), and vertical multinational firms ($v$). In equilibrium, some of these firms may not exist (depending upon absolute and relative factor endowments and parameter values). These will be reflected in three sets of components in the first of two RHS bracketed terms in equation (1) below:

$$V_i = \left[ \sum_{j=1}^{3} n_j \left( \frac{x_{ji}^n}{1 + \tau_{Xji}} \right) \right]^{\epsilon - 1} + \sum_{j=1}^{3} h_{3,ij} \left( x_{ji}^{h_3} \right)^{\epsilon - 1} + \sum_{j \neq i}^{3} h_{2,ji} \left( x_{ji}^{h_2} \right)^{\epsilon - 1} + \sum_{j \neq i}^{3} h_{2,ji} \left( x_{ji}^{h_2} \right)^{\epsilon - 1} \left[ \sum_{j=1}^{3} Y_{ji} \right]^{1 - \eta}$$

(1)

The first component reflects national (non-MNE) firms, or NEs, that can produce final differentiated goods for the home market or export to foreign markets from a single plant in the country with their headquarters, where $x_{ji}^n$ denotes the (endogenous) output of country $j$’s representative national firm in industry $X$ sold to country $i$, $n_j$ is the (endogenous) number of these national firms in $j$, and $\tau_{Xji}$ is the gross (shipment) trade cost of exporting $X$ from $j$ to $i$.

The second set of components reflects horizontal multinational firms, or HMNEs, that may have plants in either two or three countries to be “proximate” to markets to avoid trade costs; HMNEs cannot export goods. Every HMNE has a plant in its headquarters country. Let $x_{ji}$ denote the output of a horizontal multinational firm producing in $i$ and selling in $i$, $h_{i,j}$ denote the (endogenous) number of multinationals that produce in all three countries and are headquartered in $j$ ($j = 1, 2, 3$), $h_{2,ij}$ denote the number of two-country multinationals headquartered in $i$ with a plant also in $j$, and $h_{2,ji}$ denote the number of two-country multinationals headquartered in $j$ with a plant also in $i$. Hence, $x_{i,j}^{h_2}$ is output produced in country $i$ (and consumed in $i$) of the representative three-country HMNE headquartered in country $j$ and $x_{ij}^{h_2}$ is the output produced in country $i$ (and consumed in $i$) of the representative two-country multinational firm either headquartered in $i$ with a plant also in $j$ or headquartered in $j$ with a plant also in $i$. Note that $h$ plants arise when market size in one of the three countries is insufficient to warrant a local plant, and is more efficiently served (given transport and investment costs) by its own national firms and imports from foreign firms.

The third component reflects vertical multinational firms, or VMNEs. VMNEs have headquarters in one country and a plant in one of the other countries, just not in the headquarters country. The primary motivation for a vertical MNE is “cost differences”; different relative factor intensities and relative factor abundances motivate
separating headquarters from production into different countries. Let \( v_{ij} \) denote the number of vertical multinational firms with headquarters in \( k \), a plant in \( j \), and output can be sold to any country (including \( k \)). Let \( x_{ji} \) denote the output of the representative VMNE with production in \( j \) and consumption in \( i \).\(^{16}\)

In the second bracketed RHS term, let \( Y_{ji} \) denote the output of the homogenous good (e.g., agriculture) produced in country \( j \) under constant returns to scale using unskilled labor and consumed in \( i \). Let \( t_{Xji} (t_{Yji}) \) denote the gross trade cost for shipping final differentiated (homogeneous) good \( X (Y) \) from \( j \) to \( i \); let \( t_{Zji} \) be defined for intermediates similarly.\(^{17}\) Let \( t_{Xji} = 1 \) for \( i = j \), and analogously for \( t_{Yji} \) and \( t_{Zji} \). It will be useful to define gross trade costs as follows:

\[
\begin{align*}
    t_{Xji} &= (1 + b_{Xji})(1 + \tau_{Xji}) \\
    t_{Yji} &= (1 + b_{Yji})(1 + \tau_{Yji}) \\
    t_{Zji} &= (1 + b_{Zji})(1 + \tau_{Zji})
\end{align*}
\]

where \( \tau \) denotes a “natural” trade cost of physical shipment (cif/fob - 1) of the “iceberg” type, while \( b \) represents a “policy” trade cost (i.e., tariff rate) which generates potential revenue. For instance, \( b_{Xji} \) denotes the tariff rate (e.g., \( 0.05=5\% \)) on imports from \( j \) to \( i \) in differentiated final good \( X \).

The budget constraint of the representative consumer in country \( i \) is assumed to be:

\[
\sum_{j=1}^{3} n_j p_{Xji} x_{ji} + \sum_{j=1}^{3} h_{iji} p_{Xji}^h x_{ji}^h + \sum_{j=1}^{3} h_{iji} p_{Xji}^h x_{ji}^h + \sum_{j=1}^{3} h_{iji} p_{Xji}^h x_{ji}^h + \sum_{j=1}^{3} h_{iji} p_{Xji}^h x_{ji}^h + \sum_{j=1}^{3} \sum_{k=1}^{3} v_{ji} p_{Xji}^v x_{ji}^v + \sum_{j=1}^{3} p_{Yji} Y_{ji} \]

\[
= r_i K_i + w_i S_i + w_{ij} U_i + \sum_{j=1}^{3} n_j b_{Xji} p_{Xji}^{n+} x_{ji}^{n+} + \sum_{k=1}^{3} \sum_{j=1}^{3} v_{ji} b_{Xji} p_{Xji}^{v+} x_{ji}^{v+} + \sum_{j=1}^{3} b_{Yji} p_{Yji} Y_{ji} + \sum_{j=1}^{3} o_{ji} b_{Zji} p_{Zji} z_{ji}
\]

where \( p_{Xji}^{n+} (p_{Xji}^{v+}) \) denotes the price charged by the representative 3-country (2-country) horizontal MNE with a plant in \( i \). Let \( p_{Xji}^{n+}, p_{Xji}^{v+}, p_{Yji}, \) and \( p_{Zji} \) denote the prices charged by producers in \( j \) for goods \( X \) (national firms and vertical MNEs,

\(^{16}\)Recently, some researchers have considered hybrid MNEs, cf., Yeaple (2003), Grossman, Helpman, and Szeidl (2003), and Ekholm, Forslid, and Markusen (2007). The focus of these papers is much different than ours; they demonstrate conditions when an MNE pursues both horizontal and vertical integration. Research there has been directed towards understanding more clearly how multinational firms endogenously become “hybrids” in the presence of intermediate goods production and a third country. The goal of their research is to examine theoretically the sectoral factors, such as transport costs, investment costs, and headquarters setup relative to plant setup costs, driving the “optimal” structure of a multinational firm, in terms of location of plants and headquarters. Our model here could be enriched by allowing hybrid MNEs, but at a high cost of introducing a complexity that would obscure the main issues of this paper. We leave this for future research.

\(^{17}\)For modeling convenience, we define \( Y_{ji} \) net of trade costs; trade costs \( t_{Yji} \) surface explicitly in the factor-endowment constraints in Appendix A.
respectively), Y, and Z, respectively. The first three RHS terms denote factor income; the last four RHS terms denote tariff revenue redistributed lump-sum by the government in i back to the representative consumer. Let \( r \) denote the rental rate for capital in i, \( K_i \) is the capital stock in i, \( w_s (w_{us}) \) is the wage rate for skilled (unskilled) workers in i, and \( S_i (U_i) \) is the stock of skilled (unskilled) workers in i. Let \( \sigma_i \) denote the number of intermediate good producers in country j.

Maximizing (1) subject to (2) yields the domestic demand functions:

\[
x_{il}^\ell \geq \left( p_{Xi}^\ell \right)^{\epsilon-1} P_{Xi}^{-\epsilon} \eta E_i \ ; \ \ell = \{n, h_3, h_2, v\}
\]

where \( E_i \) is the income (and expenditure) of the representative consumer in country i from eq. (2), and

\[
P_{Xi} = \left[ \sum_{j=1}^{3} n_j \left( t_{Xji} p_{Xji}^n \right)^\epsilon + \sum_{j=1}^{3} h_{3,j} \left( p_{Xji}^h \right)^\epsilon + \sum_{j=1}^{3} h_{2,j} \left( p_{Xji}^h \right)^\epsilon + \sum_{j=1}^{3} h_{2,j} \left( p_{Xji}^h \right)^\epsilon + \sum_{k=j}^{3} \sum_{j=1}^{3} v_{kj} \left( t_{Xji} p_{Xji}^v \right)^\epsilon \right]^{\frac{1}{\epsilon}}
\]

is the corresponding CES price index. Following the literature, we assume that all firms producing in the same country face the same technology and marginal costs and we assume complementary-slackness conditions (cf., Markusen, 2002). Hence, the mill (or ex-manufacturer) prices of all varieties in a specific country are equal in equilibrium. Then, the relationship between differentiated final goods produced in j and at home is:

\[
\frac{x_{ji}}{x_{ii}} = \left( \frac{p_{Xji}}{p_{Xi}^v} \right)^{\epsilon-1} t_{Xji}^\epsilon (1 + b_{Xji})^{-1}
\]

Hence, from now on we can omit superscripts for both prices and quantities of differentiated products for the ease of presentation. It follows that homogeneous goods demand is:

\[
\sum_{j=1}^{3} Y_{ji} \geq \frac{1 - \eta}{P_{Yi}} E_i
\]

where \( Y_{ji} \) denotes output of the agriculture good of county j demanded in country i.

**B. Final Differentiated Good Producers**

We assume that final goods can be produced in all three countries, composed potentially of intermediates
from all three countries and three primary factors: skilled labor, unskilled labor, and physical capital. Each country is assumed to be endowed with exogenous amounts of skilled labor and unskilled labor, which are internationally immobile. We assume an exogenous world endowment of physical capital which is mobile internationally; physical capital moves endogenously across countries to maximize MNEs’ profits. Thus, we model explicitly the endogenous determination of bilateral FDI flows. Final differentiated goods producers operate in monopolistically competitive markets, similar to Markusen (2002, Ch. 6); intermediates will be discussed later in section D.

An important distinction of our model from the 2x2x2 Knowledge-Capital model is that we introduce the third factor, physical capital. As summarized in Markusen (2002), the 2x2x2 model has tended to use skilled labor and unskilled labor as its two internationally immobile factors. Other papers in this literature have used labor and capital, but with the latter usually assumed internationally immobile. Yet, all formal models in this class have had only two factors. Two critical assumptions for our theoretical results that follow are the existence of a third, internationally mobile factor – physical capital – and that any headquarter’s setup (fixed cost) requires home skilled labor – to represent the notion of R&D – and any plant’s setup in any country requires the home country’s physical capital – to represent the resources needed for a domestic or foreign direct investment.18

Assume the production of differentiated final good $X$ is given by the nested Cobb-Douglas-CES technology:

$$F_{X_i} = B(K_{X_i}^{\alpha} + S_{X_i}^{\delta})^{\frac{\alpha}{\delta}} (U_{X_i}^{\delta} + Z_{X_i}^{\delta})^{\frac{\delta}{\delta}}$$

where $F_{X_i}$ denotes production of final goods for both the domestic and foreign markets; we assume MNEs and national enterprises (NEs) have access to the same technology. $K_{X_i}$, $S_{X_i}$, $U_{X_i}$, and $Z_{X_i}$ denote the quantities used of physical capital, skilled labor (or human capital), unskilled labor, and intermediates, respectively, in country $i$ to produce $X$. The specific form of the production function is motivated by three literatures. First, the Cobb-Douglas function is useful in characterizing analytically and empirically the relatively constant production shares of capital and labor. Second, early work by Griliches (1969) indicates that physical capital and human capital tend to be complements, rather than substitutes, in technology; recent evidence for this in the MNE literature is found in Slaughter (2000). This suggests nesting a CES production function within the Cobb-Douglas function to allow for the potential complementarity or substitutability of physical and human capital. Third, recent work on outsourcing suggests that intermediate goods are substitutes for unskilled labor; the second CES sub-production function allows the elasticity of substitution between intermediates and unskilled labor to exceed unity. As the latter two issues are less known to trade economists, we address them in more

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18 Note that, while physical capital can be “utilized” in different countries, the “ownership” of any country’s endowment of such capital is immobile. In the typical 2x2x2 model, headquarters use home skilled labor exclusively for setups; home (foreign) plants use home (foreign) labor for setups (cf., Markusen, 2002, p. 80). With only immobile skilled and unskilled labor, these models naturally preclude home physical capital being utilized to setup foreign plants.
depth in section IV when we describe the calibration of the numerical general equilibrium (GE) model.

National firms and MNEs differ in fixed costs. Each NE incurs only one firm setup and one plant setup; each MNE incurs one firm setup (the cost of which is assumed larger than that of a NE, as in Markusen, 2002) and a plant setup for its home market and for each foreign market it endogenously enters. A horizontal MNE has a headquarters at home and plants potentially in either two or three markets to serve them; it has no exports. A vertical MNE has a headquarters at home and one plant abroad, which can export to any market.

Let \( Z_{Xi} \) denote the CES aggregate of intermediate inputs:

\[
Z_{Xi} = \left[ \sum_{j=1}^{3} o_{ij} \left( \frac{z_{ji}}{t_{Zi}} \right)^{\frac{\theta-1}{\theta}} \right]^{\frac{1}{\theta}},
\]

where \( z_{ji} \) denotes the output of the representative firm in country \( j \) supplying intermediates goods to country \( i \) and \( \theta < 0 \). The corresponding CES price index for \( Z_{wi} \) is:

\[
P_{Zi} = \left[ \sum_{j=1}^{3} o_{ij} \left( t_{Zi} P_{zij} \right)^{\theta} \right]^{\frac{1}{\theta}}
\]

Maximizing profits subject to the above technology yields the following conditional factor demands (denoted with *) and input coefficients:

\[
K^*_{Xi} = F_{Xi} \left( \frac{w_{Ui}}{r_i} \frac{1}{1-\alpha} \right)^{1-\alpha} \frac{\alpha (\chi - 1) - \chi}{T_{li}} \frac{(1-\alpha)(\delta - 1)}{T_{2i}^\delta} \frac{a_{KXi}}{a_{KXi}}
\]

\[
S^*_{Xi} = F_{Xi} \left( \frac{w_{Ui}}{w_{Si}} \right)^{1-\alpha} \frac{\alpha (\chi - 1)}{T_{2i}^\delta} \frac{\alpha (\chi - 1)-\chi}{T_{3i}^\chi} \frac{a_{SXi}}{a_{SXi}}
\]

\[
U^*_{Xi} = F_{Xi} \left( \frac{r_i}{w_{Ui}} \frac{1}{1-\alpha} \right)^{\alpha} \frac{\alpha (\chi - 1)}{T_{li}^\chi} \frac{\alpha (1-\delta) - 1}{T_{2i}^\delta} \frac{a_{UXi}}{a_{UXi}}
\]

\[
Z^*_{Xi} = F_{Xi} \left( \frac{r_i}{P_{zij}} \frac{1}{1-\alpha} \right)^{\alpha} \frac{\alpha (\chi - 1)}{T_{li}^\chi} \frac{\alpha (1-\delta) - 1}{T_{4i}^\delta} \frac{a_{ZXi}}{a_{ZXi}}
\]

where B is a constant and we introduce definitions:
Of course, in the context of the model, there is costless intra-firm exchange of intangible assets of MNEs.
MNE trade is no more than 30 percent of international offshoring. Finally, Bernard, Jensen, and Schott (2005) provide data for the United States for 1993 and 2000 and show that intra-firm trade as a share of MNEs’ trade was virtually constant from 1993 to 2000, precluding an increased intra-firm trade share as a possible source of increased FDI to final goods trade. These studies confirm the importance of intermediates trade among unaffiliated firms. To be consistent with these observations (while also limiting the model’s complexity and scope), we model intermediates trade as among unaffiliated firms, even though we still allow vertical MNEs to export final goods from a foreign plant to a home country’s consumer.20

We assume that differentiated intermediate products for the (national) representative (type o) firm in country i are produced in monopolistically-competitive markets given a Cobb-Douglas technology:

\[ z_i = A S_z^\beta U_z^{1-\beta} \]  

(12)

where \( z_i \) denotes production of intermediate goods for both the domestic and foreign markets. Local intermediate goods supply from a single intermediate goods producer in market \( i \) for local demand is referred to as \( z_{io} \) whereas supply to (and, in equilibrium, demand gross of transport costs in) a foreign market \( j \) is denoted by \( z_{ij} \). As for national final goods exporters, any (national) intermediate firm incurs one headquarters setup and one plant setup.21 The above technology yields the following conditional factor demands and input coefficients:

\[ S_{Zi}^* = z_i \left( \frac{1}{A} \right) \left( \frac{w_{U_i}}{w_{S_i}} \right)^{1-\beta} \]

\[ U_{Zi}^* = z_i \left( \frac{1}{A} \right) \left( \frac{w_{U_i}}{w_{S_i}} \right)^{\beta} \]

(13a-13b)

An intermediate goods producer in the intermediate goods market equilibrium is faced with local (domestic) demand:

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20In the future, one could also allow intra-firm trade in intermediates, as in Markusen (2002, ch. 9). However, at this time, this would introduce yet another level of complexity well beyond the scope of this already fairly-intricate model.

21One might argue that – since we are precluding multinational firms in producing intermediates – there might be no reason to distinguish headquarters fixed costs from plant fixed costs, as is done for national firms producing final goods. However, as will be apparent shortly in equations (16a)-(16c), the input requirements are general enough simply to allow different relative factor requirements of human and physical capital in the setups of headquarters and plants for national final good and national intermediate good producers. For now, we allow each intermediates producer to “setup” a headquarters (to research, advertise, or distribute its product) and a plant.
\[
\begin{align*}
\varepsilon_{ij} & \geq \left( \frac{p_{Zi}}{p_{Zj}} \right)^{1-\theta} a_{ZXi} \left[ n_i \sum_{j=1}^{3} x_{ij} + x_{ii} \left( \sum_{j=1}^{3} h_{3,j} + \sum_{j \neq i} h_{2,ji} + \sum_{j \neq i} h_{2,j} \right) + \sum_{j \neq i} v_{ji} \left( \sum_{j=1}^{3} x_{ij} \right) \right] \\
\text{(14)}
\end{align*}
\]

and the relationship between foreign and domestically sourced intermediates is:

\[
\frac{z_{ji}}{z_{ii}} = \left( \frac{p_{Zi}}{p_{Zj}} \right)^{1-\theta} t_{Zji}^\theta \left( 1 + b_{Zji} \right)^{-1}
\]

\[
\text{(15)}
\]

E. Profit Functions and Pricing Equations

All firms are assumed to maximize profits given the technologies assumed and the demand curves suggested above. The profit functions are:

\[
\pi_{oi} = (p_{Zi} - c_{Zi}) \sum_{j=1}^{3} z_{ij} - a_{Soi} w_{Si} - a_{Koi} r_i
\]

\[
\pi_{mi} = (p_{Xi} - c_{Xi}) \sum_{j=1}^{3} x_{ij} - a_{Smi} w_{Si} - a_{Kmi} r_i
\]

\[
\pi_{h3,i} = \sum_{j=1}^{3} (p_{Xj} - c_{Xj}) x_{jj} - a_{Smj} w_{Si} - a_{Kmi} [3 + \sum_{j \neq i} \gamma_{ij}] r_i
\]

\[
\pi_{h2,ij} = (p_{Xj} - c_{Xj}) x_{ii} + (p_{Xj} - c_{Xj}) x_{jj} - a_{Smj} w_{Si} - a_{Kmi} [2 + \gamma_{ij}] r_i
\]

\[
\pi_{v,ij} = (p_{Xj} - c_{Xj}) \sum_{k=1}^{3} x_{jk} - a_{Smj} w_{Si} - a_{Kmi} [1 + \gamma_{ij}] r_i
\]

\[
\text{(16a-16e)}
\]

Eq. (16a) is the profit function for an intermediate goods producer in country \(i\). Let \(c_{Zi}\) denote marginal costs of intermediate goods production in \(i\) and the latter two RHS terms represent fixed (domestic) skilled labor and physical capital costs for the intermediate goods producer to setup a headquarters and a plant. Eq. (16b) is the profit function
for each national final goods enterprise (NE) in \( i \). Let \( c_{Xi} \) denote marginal production costs of differentiated final good \( X \) in country \( i \) and the latter two RHS terms represent fixed human and physical capital costs for the national enterprise final goods producer. Eq. (16c) is the profit function for each horizontal final-good-producing multinational firm in country \( i \) with three operations (one in the parent country and one in each of two foreign markets). The last two terms in (16c) represent fixed costs of each 3-country horizontal MNE. As with previous firms, the MNE incurs a single fixed cost of home skilled labor to setup a firm. However, each 3-country MNE incurs a fixed cost of home physical capital for each plant. Moreover, each foreign investment incurs a potential investment cost \( \gamma \) (say, policy or natural foreign direct investment barrier). Eq. (16d) is the profit function for each horizontal final-good-producing multinational firm in country \( i \) with two operations (one at home). Finally, eq. (16e) is the profit function for a vertical MNE with a headquarters in \( i \) and a plant in \( j \).

A key element of our model is that – in each country – the numbers of national intermediates producers (type \( o \)), national final goods enterprises (type \( n \)), three-country horizontal MNEs (type \( h_3 \)), two-country horizontal MNEs (type \( h_2 \)), and vertical MNEs (type \( v \)) are endogenous to the model. Two conditions characterize models in this class. First, profit maximization ensures markup pricing equations:

\[
P_{Zi} \leq \frac{c_{Zi}(\theta - 1)}{\theta} \quad p_{Xi} \leq \frac{c_{Xi}(\epsilon - 1)}{\epsilon}
\]

Second, free entry and exit ensures:

\[
\begin{align*}
    a_{Soi}w_{Si} + a_{Koi}r_i &\geq \frac{c_{Zi}(\theta - 1)}{\theta} \sum_{j=1}^{3} z_{ij} \\
    a_{Soi}w_{Si} + a_{Kni}r_i &\geq \frac{c_{Xi}(\epsilon - 1)}{\epsilon} \sum_{j=1}^{3} x_{ij} \\
    a_{Soi}w_{Si} + a_{Kmi} \left[3 + \sum_{i \neq j} \gamma_{ij}\right]r_i &\geq \sum_{j=1}^{3} \frac{c_{Xi}(\epsilon - 1)}{\epsilon} x_{ij} \\
    a_{Smj} w_{Si} + a_{Kmj} \left[2 + \gamma_{ij}\right] r_i &\geq \frac{c_{Yi}(\epsilon - 1)}{\epsilon} x_{ii} + \frac{c_{Xi}(\epsilon - 1)}{\epsilon} x_{ij} \\
    a_{Smj} w_{Si} + a_{Kmj} \left[1 + \gamma_{ij}\right] r_i &\geq \frac{c_{Yi}(\epsilon - 1)}{\epsilon} \sum_{k=1}^{3} x_{jk}
\end{align*}
\]

F. Factor-Endowment and Current-Account-Balance Constraints

We assume that, in equilibrium, all factors are fully employed and that every country maintains multilateral (though not bilateral) current account balance; endogenous bilateral current account imbalances allow for endogenous
bilateral FDI of physical capital. Following the established literature, this is a static model. The formal factor-endowment and multilateral current-account-balance constraints are provided in Appendix A.

IV. Calibration of the Model

The complexity of the model, including the complementary-slackness conditions shown, introduces a high degree of nonlinearity, and it cannot be solved analytically. Consequently, we provide numerical solutions to the model, as in Markusen (2002) and related studies. In order to address interesting issues, we can potentially employ our 3-country model to distinguish among four different scenarios: (i) bilateral trade and FDI flows between two developed economies, or intra-DC flows (with a less developed third country, or LDC); (ii) bilateral flows from a DC to an LDC (with a developed third country); (iii) bilateral flows from a LDC to a DC (with a developed third country); and (iv) bilateral flows from a LDC to another LDC, or intra-LDC flows (with a developed third country).

A key consideration is that—due to the nonlinearities of the model—the marginal effects of bilateral economic sizes, relative factor endowment differences, and transaction costs on bilateral trade and investment flows will differ depending upon the economic characteristics of the ROW. As the stylized facts in section II suggest though, we focus on intra-DC (or OECD) flows, reserving analysis of DC-LDC flows and intra-LDC flows for future work. We use GAMS for our numerical analysis.

A. Exogenous Variables

Our intent is to keep as close to the spirit of modern GE models of multinational firms as possible. In this regard, we note the following assumptions made about the exogenous variables in our model.22

For analytical purposes, the relative size of endowments among the three countries matters. We assume a world endowment of capital ($K$) of 240 units, skilled labor ($S$) of 90 units, and unskilled labor ($U$) of 100 units. In our case studying intra-DC trade, $ROW$ represents the developing world. Initially, we set country i’s (j’s) relative shares of the world endowments of physical capital and skilled labor at 1/3 (1/3) and $ROW$’s at 1/3, and country i’s (j’s) share of unskilled labor at 1/4 (1/4) and $ROW$’s at 1/2. Hence, both DCs are capital- and skilled-labor abundant relative to $ROW$.

We appealed to actual trade data to choose initial values for transport costs (rather than choosing values arbitrarily as in the literature). Using the United Nations’ (UN’s) COMTRADE data, we aggregated bilateral 5-digit Standard International Trade Classification (SITC) trade flows into aggregate bilateral intermediate goods and

22 It is common in the GE literature to denote trade costs, investment costs and factor endowments as “parameters.” We term these “exogenous variables” here.
aggregate bilateral final goods trade flows, according to the UN’s Classification by Broad Economic Categories (2003). Using the bilateral trade data for weights, we calculated the mean final goods and intermediate goods bilateral transport cost factors \([\text{cif} - \text{fob})/\text{fob}\) for intra-DC trade, intra-LDC trade, and trade between DCs and LDCs. For final goods (differentiated or homogeneous), the transport cost factor was 7.6 percent for intra-DC trade, 19.2 percent for intra-LDC trade, 20.2 percent for trade flows from DCs to LDCs, and 20.2 percent for flows from LDCs to DCs. For intermediate goods, the transport cost factor was 9.8 percent for intra-DC trade, 21.2 percent for intra-LDC trade, 20.0 percent for trade flows from DCs to LDCs, and 20.1 percent for flows from LDCs to DCs.

We constructed initial values for tariff rates using Jon Haveman’s TRAINS data for the 1990s. Tariff rates are available at the Harmonized System 8-digit level. Using the UN’s Classification by Broad Economic Categories again, we classified tariff rates by final and intermediate goods 5-digit SITC categories. We then weighted each country’s 5-digit SITC tariff to generate average tariffs at the country level for each year 1990-2000. Tariff rates were then weighted by aggregate bilateral final goods or intermediate goods imports to obtain mean regional tariff rates, accounting for free trade agreements and customs unions. For final goods, the tariff rate was 1.1 percent for intra-DC trade, 9.3 percent for intra-LDC trade, 9.7 percent for trade from DCs to LDCs, and 4.0 percent for trade from LDCs to DCs. For intermediate goods, the tariff rate was 0.2 percent for intra-DC trade, 6.2 percent for intra-LDC trade, 6.1 percent for trade from DCs to LDCs, and 0.6 percent for trade from LDCs to DCs.

Data on bilateral costs of investment (say, informational costs) and on policy barriers to FDI are not available. Carr, Markusen, and Maskus (2001) used a country “rating” score from the World Economic Forum’s World Competitiveness Report that ranges from 0 to 100. However, ad valorem equivalent measures are not available across countries, much less over time. Consequently, we assumed values to represent informational costs and policy barriers to FDI between countries. We assumed initially a tax-rate equivalent (for \(\gamma\)) of 90 percent for intra-DC FDI, 120 percent for FDI flows from LDCs to DCs, and 140 percent for FDI flows from DCs to LDCs, but results are robust to alternative values. While these choices are somewhat arbitrary, they seem feasible in the context of recent estimates of analogous “trade costs” in Anderson and van Wincoop (2004) of 170 percent.

B. Other Parameter Values

We now discuss other parameter values assigned initially. Consider first the utility function. In equation (1), the only two parameters are the Cobb-Douglas share of income spent on final differentiated products from various producers \((\eta)\) and the CES parameter \((\varepsilon)\) influencing the elasticity of substitution between final differentiated products \((\sigma = 1 - \varepsilon)\). Initially, we use 0.71 for the value of \(\eta\). This is based upon an estimated share of manufactures trade in overall world trade averaged between 1990 and 2000 using 5-digit Standard International Trade Classification (SITC) data from the UN’s COMTRADE data set; this is a plausible estimate of the importance of differentiated products in
In fact, human and physical capital may even be absolute complements, rather than just more complementary. The choice of 0.1 was somewhat arbitrary. Empirical evidence suggests that human capital’s share of final goods production is approximately one-third. We know less about intermediates. However, we conjecture that skills are even less important in intermediates production. The results in the remainder of the paper are robust to changing this value.

Consider next production function (7) for final differentiated goods. Labor and intermediates share of final differentiated goods gross output is assumed to be 0.8, which is conventional; the Cobb-Douglas formulation implies the elasticity of substitution between capital and labor is unity. In one of a series of papers, Griliches (1969) proposed – in a three-factor world with unskilled labor, skilled labor, and physical capital – that skills (or human/knowledge capital) were more complementary with physical capital than with unskilled labor. Griliches found convincing econometric evidence that physical capital and skilled labor were relatively more complementary in production than physical capital and unskilled labor. Most evidence to date suggests that skills and physical capital are relatively complementary in production. In (to our knowledge) the only empirical study of MNE behavior considering this issue, Slaughter (2000) finds statistically significant evidence in favor of capital-skill complementarity. Initially, we assume \( \chi = -0.25 \), implying an elasticity of substitution of 0.8 and complementarity between physical and human capital.

Regarding unskilled labor and intermediates, the national debate on outsourcing among industrialized economies is basically concerned with the substitution of intermediate goods produced in relatively unskilled-labor-abundant economies (with some final processing at home) for immobile unskilled labor at home. To capture this substitutability, we allow \( 0 < \delta < 1 \); specifically, we assume an elasticity of substitution of 1.2 (\( \delta = 0.167 \)).

We assume initially that intermediate products are better substitutes for each other in production than final goods are substitutes in consumption and choose an intermediates elasticity of substitution of 8 (\( \theta = -7 \)) in equation (8). Results are robust to alternative values.

Production of intermediates uses skilled and unskilled labor. We assume this production is Cobb-Douglas, and that the cost share of skilled labor in production (\( \beta \)) is 0.1 in equation (12).

As in the 2x2x2 knowledge-capital model in Carr et al. (2001), a firm (or headquarters) setup uses only skilled labor. For national intermediates and final goods producers, we assume the headquarters setup requires a unit

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23 In fact, human and physical capital may even be absolute complements, rather than just more complementary.

24 The choice of 0.1 was somewhat arbitrary. Empirical evidence suggests that human capital’s share of final goods production is approximately one-third. We know less about intermediates. However, we conjecture that skills are even less important in intermediates production. The results in the remainder of the paper are robust to changing this value.
of skilled labor per unit of output \((a_{s01}=a_{s02}=a_{s03}=a_{s10}=a_{s11}=a_{s12}=1)\). As in the knowledge-capital model, we assume “jointness” for multinational firms; that is, services of knowledge-based assets are joint inputs into multiple plants. Markusen suggests that the ratio of fixed headquarters setup requirements for a (2-plant) horizontal or (1-plant) vertical multinational relative to a domestic firm ranges from 1 to 2. We assume initially a ratio of 1.01 \((a_{sh1} = a_{sh2} = a_{sh3} = a_{sv1} = a_{sv2} = a_{sv3} = 1.01)\). Hence, to bias the theoretical results initially in favor of multinational activity (that is, in favor of MNEs completely displacing trade), we assume the additional firm setup cost of an MNE over a national firm is quite small. We assume that every plant (national or MNE) requires one unit of home physical capital \((a_{k}=1)\). However, an MNE setting up a plant abroad can face an additional fixed investment cost \((\gamma)\), values of which were specified earlier.

V. A Theoretical Rationale for Gravity Equations of FDI, Final Goods Trade, and Intermediates Trade

We use our numerical general equilibrium model to motivate a theoretical rationale for identifying the main economic determinants of bilateral intermediate goods trade – in a manner consistent with identifying the main economic determinants of bilateral FDI and bilateral final goods trade – using gravity equations. The two critical factors in the gravity equation explaining flows are GDPs and “frictions.” We address each in turn.

A. Economic Size and Similarity

We discuss first the expected relationships between exporter (home) and importer (host) GDPs and the three types of flows suggested by our theory. However, we must first show two key features of the gravity equation. First, in a simple theoretical world of \(N (>2)\) countries, one final differentiated good, no trade costs, but internationally-immobile factors (e.g., labor and/or capital), we know from the international trade gravity-equation literature that the trade flow from country \(i\) to country \(j\) in year \(t\) \((\text{Flow}_{ijt})\) will be determined by:

\[
\text{Flow}_{ijt} = \frac{GDP_i \cdot GDP_j}{GDP_W}
\]  

where \(GDP_W\) is world GDP, or in log-linear form:

\[
\ln \text{Flow}_{ijt} = -\ln(GDP_W) + \ln(GDP_i) + \ln(GDP_j)
\]  

However, the standard frictionless trade gravity equation can be altered algebraically to separate influences of economic size \((GDP_i + GDP_j)\) and similarity \((s_is_j)\), where \(s_i = GDP_i/(GDP_i + GDP_j)\) and analogously for \(j\):

\[
\text{Flow}_{ijt} = \frac{GDP_i \cdot GDP_j}{GDP_W} = \frac{(GDP_i + GDP_j)^2 (s_is_j)}{GDP_W}
\]  

When countries \(i\) and \(j\) are identical in economic size \((s_i=s_j=1/2)\), \(s_is_j\) is at a maximum. In log-linear form, (21) is:
Gross bilateral FDI from $i$ to $j$ is for HMNEs in industry $X$, since relative factor endowments are equal between $i$ and $j$ and unchanged.

\[
\ln \text{Flow}_{ij} = -\ln(GDP_i^w) + 2\ln(GDP_i + GDP_j) + \ln(s_i s_j)
\]  

(22)

Second, while the gravity equation is familiar in algebraic form, it will be useful to visualize the frictionless “gravity” relationship. Figure 1a illustrates the gravity-equation relationship between bilateral trade flows, GDP size, and GDP similarity summarized in equation (21) for an arbitrary hypothetical set of country GDPs ($N>2$). First, we explain the figures’ axes and labeling. The lines on the y-axis in the bottom plane range from 1 to 2.2. The y-axis indexes the joint economic size of countries $i$ and $j$; line 1 denotes the smallest combination of GDPs and line 2.2 denotes the largest combination. The GDP values are scaled to this index with the range tied to our World Development Indicators data set on GDPs. The x-axis is indexed from 0 to 1. Each line represents $i$’s share of both countries GDPs; the center line represents 50 percent, or identical GDP shares for $i$ and $j$. The z-axis measures the “flow” from $i$ to $j$ as determined by equation (21), which is a simple algebraic transformation of typical (frictionless) gravity equation (19). Figure 1a illustrates the relationships between country economic size (measured by sum of GDPs of $i$ and $j$) on the y-axis, GDP similarity on the x-axis, and the “flow” from $i$ to $j$ as determined by simple frictionless gravity equation (21).

Common to Knowledge-Capital-type theoretical GE models, analytic solutions are unobtainable and we rely on numerical solutions to the GE model to obtain “theoretical” relationships, using figures generated by the numerical GE version of our model, as in Markusen (2002), Braconier, Urban and Norbäck (2005), and Bergstrand and Egger (2007). We can now focus on the bilateral relationships between two economies with identical bilateral relative factor endowments and transaction cost levels. That is, we can examine using the numerical model the relationships between economic size (sum of GDPs of $i$ and $j$) and GDP similarity with bilateral final goods exports from $i$ to $j$ ($X_{ij}$), bilateral intermediate goods exports from $i$ to $j$ ($Z_{ij}$), and the bilateral foreign direct investment flow from $i$ to $j$ ($FDI_{ij}$), shown in Figures 1b, 1c, and 1d, respectively.25

**Proposition 1**

First, we note in Figures 1b-1d that (gross) bilateral final goods trade, intermediate goods trade, and FDI from $i$ to $j$, respectively, are all positive monotonic functions of the size of the two countries’ GDPs, as the gravity equation suggests for a given GDP-row (cf., Figure 1a). For any given share of $i$ in $i$’s and $j$’s total GDP, an increase in the absolute endowments of both countries increases their bilateral final goods trade, bilateral intermediate goods trade, and FDI flow. The numbers of NEs and HMNEs increase monotonically with a larger joint economic size (Sum of GDPs of $i$ and $j$); figures are omitted for brevity, but are available on request. More resources cover more

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25Gross bilateral FDI from $i$ to $j$ is for HMNEs in industry $X$, since relative factor endowments are equal between $i$ and $j$ and unchanged.
setup costs of final and intermediate goods NEs and of HMNEs; economies of scale and love of variety for consumers and intermediates specialization for producers expand the number of total varieties produced for all three countries by both types of firms in \( i \). This is testable Proposition 1.

**Proposition 2**

Second, we note that final goods, intermediate goods, and FDI flows from \( i \) to \( j \) are all positively related to the similarity of economic sizes. This is testable Proposition 2. With the exception of FDI, final goods and intermediate goods trade flows from \( i \) to \( j \) are maximized when countries \( i \) and \( j \) are identically sized; this is a traditional feature of the gravity equation. In the case of FDI, the flow from \( i \) to \( j \) is maximized when \( i \) is slightly larger than \( j \); this subtle feature of FDI will be addressed shortly below. Thus, the surfaces suggest that (using aggregate bilateral final goods, intermediates, and FDI flows) the flows are all complements, even though final goods trade and FDI are inherently substitutes. What explains this?

The intuition can be seen by starting at the far right-hand-side (RHS) of Figures 1b-1d, when \( j \)’s GDP is small relative to \( i \)'s. When \( j \)'s GDP share becomes positive (via an exogenous reallocation of initial factor endowments from \( i \) to \( j \), \( j \)'s relatively small (final) consumer market is most profitably served by exports from national final goods firms in \( i \) and some domestic production in \( j \). In contrast to Bergstrand and Egger (2007) which had no intermediates, intermediates trade from \( i \) to \( j \) also increases as domestic production in \( j \) uses differentiated intermediates from home and foreign producers. As \( i \)'s (\( j \)'s) share of their combined GDPs gets smaller (larger), the number of exporters and varieties in \( i \) and overall demand in \( j \) expand (figures not shown), such that exports from \( i \) to \( j \) of final and intermediate goods increase.

At some point (around 0.75 on the x-axis), as \( i \)'s (\( j \)'s) GDP share gets even smaller (larger), it becomes more profitable for \( i \) to serve \( j \)'s market using HMNEs based in \( i \); hence, FDI from \( i \) to \( j \) increases. Since the number of HMNEs increases, the demand for intermediates increases. While in the Markusen 2x2x2 KC model, the increase in HMNEs would eventually completely displace national final goods exporters in \( i \), the increase in multi-plant HMNEs in our model leads to a fall in the relative demand and price of unskilled labor and a rise in the relative demand and price of physical capital in \( i \); figures are not shown for brevity, but are available on request. These relative factor price changes in \( i \) curb the creation of HMNEs in \( i \) as \( i \)'s GDP-share gets smaller and curb the displacement of final goods national exporting firms in \( i \), such that national final goods exports in \( i \), national intermediate goods exports, and HMNEs based in \( i \) with production in \( j \) can all coexist as the GDPs of countries \( i \) and \( j \) become identical.\(^{26}\)

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\(^{26}\)The small temporary dip in intermediates exports from \( i \) to \( j \) as \( j \)'s GDP share increases toward \( \frac{1}{2} \) in Figure 1c is easily explained, and demonstrates the richness of the model’s interactions. First, we note that intermediate goods exports from \( j \) to \( i \) (not shown for brevity) is the mirror image of Figure 1c, where consequently the “wrinkle” would occur at \( i \)'s GDP-share of
Proposition 3

Overall, Figures 1b-1d suggest a theoretical rationale for explaining gross bilateral final goods trade, intermediates trade, and FDI flows from \( i \) to \( j \) in terms of the product of GDPs of \( i \) and \( j \) (or, size and similarity). However, a third subtler issue is that the gross FDI flow from \( i \) to \( j \) is not maximized when \( i \) and \( j \) are identically sized. Rather, the theoretical model suggests that FDI from \( i \) to \( j \) should be maximized when \( i \)’s share is larger than \( j \)’s. This is consistent intuitively with the notion that profit-maximizing firms in \( i \) will want to serve relatively small market \( j \) using HMNEs rather than exports, once \( j \) crosses a minimum market-size threshold. This is testable Proposition 3.

B. Trade and Investment Costs

While gravity equations typically include bilateral distance and several dummy variables to reflect trade and investment frictions, our theoretical model includes bilateral iceberg-type final goods trade costs, intermediate goods trade costs, and investment costs (FDI barriers). Moreover, as discussed earlier, we have time-varying empirical measures of all three variables, allowing some testable propositions.

Proposition 4

For all types of flows, the own-price effect should be negative. Final goods trade from \( i \) to \( j \) should be a negative function of natural (such as transport) final goods trade costs between \( i \) and \( j \). Intermediate goods trade from \( i \) to \( j \) should be a negative function of intermediate goods trade costs between \( i \) and \( j \). FDI from \( i \) to \( j \) should be a negative function of FDI barriers between \( i \) and \( j \). These effects are straightforward and figures (omitted for brevity) confirm these conjectures. These three predictions form testable Proposition 4.

Proposition 5

Regarding cross-price effects, in most cases economically conflicting effects are potentially at play; however, there is one unambiguous prediction. An increase in the barrier to FDI (final goods trade cost) from \( i \) to \( j \)
should be positively related to final goods exports (FDI) from $i$ to $j$. These relationships are expected since horizontal FDI and final goods trade are gross substitutes (with respect to prices). This forms testable Proposition 5.

The remaining cross-price effects are ambiguous. Consider for instance the effect of intermediate goods trade costs on final goods. An increase in intermediate goods trade costs from $i$ to $j$ will tend to increase the cost and price of final good exports, tending to reduce final goods exports from $i$ to $j$. However, in general equilibrium a rise in intermediate trade costs, by reducing demand for intermediate goods and factors of production, makes production of final goods more competitive, potentially increasing final goods exports from $i$ to $j$.

Consider next the cross-price effects of final goods trade costs on intermediate goods trade from $i$ to $j$. An increase in final goods trade costs between $i$ to $j$ should reduce demand for final goods exports from $i$ to $j$ and $j$ to $i$, reducing demand for intermediate products from $j$ to $i$ and $i$ to $j$; intermediates trade from $i$ to $j$ could decline. However, the change in relative prices could make intermediate goods production more competitive, potentially increasing intermediates trade from $i$ to $j$.

Similar ambiguities arise for the cross-price effects on FDI from $i$ to $j$. However, for brevity discussion of these effects is omitted (but available on request).


In this section, we evaluate empirically the five “testable” propositions identified in section V. In part A, we describe the data set we used to estimate the relationships and the other RHS variables we included to avoid specification error. Note, of course, that the theoretical figures generated by our numerical CGE model in section V implicitly hold constant all other factors influencing trade and FDI, notably the usual costs of trade and investment associated with frictions such as distance and language. In part B, we provide the empirical results and evaluate the testable propositions. Part C provides a summary of an analysis for robustness of the results.

A. Specifications and Data

To evaluate these five testable propositions, we run typical log-linear gravity equations using pooled cross-section time series data for the period 1990-2000. We specify traditional gravity equations for the log of the gross flow from $i$ to $j$ for either final goods trade, intermediate goods trade, or FDI on the LHS. The RHS variables can be decomposed into three groups. The first group is the log of the exporter GDP and log of the importer GDP. The second group includes explicit time-varying measures of logs of final goods trade costs (bilateral cif-fob factors for

\footnote{Regarding vertical trade, an increase in this FDI barrier would tend to reduce final goods exports from $j$ to $i$, but not $i$ to $j$.}
final goods trade), intermediate goods trade costs (bilateral cif-fob factors for intermediate goods trade), and a measure of the costs of foreign direct investment (to be described below). The third group includes traditional bilateral “friction” variables (controls): log of bilateral distance between economic centers, a dummy variable for adjacency (sharing a common land border), and a dummy for sharing a common language.

We now summarize the data used. The trade flow data were described earlier in section II. The outward FDI (stock) data were constructed from UNCTAD data (country profiles). GDP data are from the World Bank’s World Development Indicators. Bilateral distances are from the CEPII data base in France. The adjacency and language dummies were compiled using the CIA World Factbook. Time-varying final goods and intermediate goods bilateral cif-fob factors were computed using import and export data from our trade flow data set. The time-varying investment cost index is that used in Carr, Markusen and Maskus (2001), Markusen (2002), and Markusen and Maskus (2001, 2002), and was kindly provided by Keith Maskus.

It is important to emphasize that the theoretical surfaces describing the relationships between trade and FDI flows from $i$ to $j$ are based upon the results of a numerical model where countries $i$ and $j$ are initially identical in all respects (and ROW is a developing economy, representing a group of developing economies). Consequently, the three theoretical propositions relating flows from $i$ to $j$ to the two countries’ economic sizes and economic similarities are based upon two developed countries’ GDPs, assuming the two countries’ relative factor endowments are identical and unchanging. Consequently, while we computed final and intermediates trade flows among 160 countries, we would only expect the testable propositions to hold for a group of similar, advanced economies, such as members of the OECD. Consequently, in our basic results we examine only trade and FDI flows among all 24 member countries of the OECD (in 1990, there were only 24 members). We will, however, provide some results in the sensitivity analysis for trade and FDI flows with and among non-OECD countries, noting that we have no prior expectations for such flows (the analysis of which is beyond the scope of this already lengthy paper and the subject of future research).

### B. Empirical Results

Table 3 reports the gravity equation estimates for the three types of flows among OECD countries. We discuss the results for this table in the order above for Propositions 1-5.

First, we report the GDP elasticities for the exporter (home) and importer (host) countries. The coefficient estimates for GDPs are positively signed and are statistically significant. These elasticity estimates confirm Proposition 1 that bilateral final goods trade, intermediate goods trade, and FDI flows are positively related to the economic size of the two countries.

Second, in light of the discussion at the beginning of section V, the similarly sized GDP coefficient estimates for exporter and importer countries tend to confirm the second proposition as well; final goods and intermediate goods
This can be shown algebraically.

trade flows are increasing in similarity of economic size. However, for the two trade flows in Table 3, the coefficient estimate for exporter GDP is slightly larger than that for importer GDP. Yet theoretical Figures 1b and 1c suggested that the gross trade (FDI) flows should be maximized when the two countries are identically sized (when $i$ is larger than $j$). To provide further confirmation of Proposition 2, we illustrate in Figure 2 the predicted values from all three regressions reported in Table 3. In particular, Figures 2a and 2b provide the predicted empirical final goods and intermediate goods trade flows, respectively, based upon the regression equations. Figures 2a and 2b are strikingly similar to the corresponding predicted theoretical trade flows generated by the numerical version of our general equilibrium model, where the data for GDP size and similarity are based upon our empirical distributions using actual GDP data (1b and 1c). In Figures 2a and 2b, (predicted empirical) final goods and intermediate goods trade flows are indeed maximized when the two countries are identically sized.

Third, Table 3 reveals that the difference in the home and host countries’ GDP coefficient estimates for FDI from $i$ to $j$ is the largest of the three regressions. A larger elasticity estimate for the home country’s GDP compared to that of the host country’s GDP implies that the FDI flow should be maximized when $i$’s share of the two countries’ GDP is larger. Figure 2c confirms using the predicted empirical values of FDI flows based upon the regression equation that FDI from $i$ to $j$ is indeed maximized when $i$’s GDP share is larger than $j$’s share. This confirms Proposition 3, and is consistent with Figure 1d in the theory that FDI is maximized when $i$’s share is larger.

Fourth, the third, fourth and fifth rows of Table 3 provide the coefficient estimates for the own-price effects of bilateral final goods trade costs, bilateral intermediate goods trade costs, and (multilateral) investment costs, respectively (no measure of bilateral investment costs is available). Proposition 4 stated that the own price effects should all be negative. The results for the own-price effects in Table 3 confirm this proposition robustly. For final goods exports, final goods trade costs have an economically and statistically significant negative effect on such trade. Intermediate goods trade costs from $i$ to $j$ have an economically and statistically significant negative effect on intermediate goods exports from $i$ to $j$ as expected. Also, the investment cost index has an economically and statistically significant negative effect on outward FDI from $i$ to $j$. Proposition 4 is confirmed with strong statistical support.

Fifth, the only testable proposition for cross-price effects was an expected positive coefficient estimate for the effect of investment (final goods trade) costs on final goods trade (FDI). Proposition 5 is confirmed only for investment costs’ effect on final goods trade, and that coefficient estimate is neither economically nor statistically significant.

Finally, we note that the coefficient estimates for standard control variables for trade and investment
“frictions” – bilateral distance, adjacency dummy, and language dummy – generally accord with earlier studies, even though our theoretical model is agnostic on these variables (as in Markusen, 2002), and the $R^2$ values are in line with these studies. The negative coefficient estimates for bilateral distance are in line with previous estimates and are statistically significant. The coefficient estimate for the adjacency dummy has the typical sign for final goods, but is statistically insignificant. Since no previous studies have used the gravity model for intermediate goods trade flows, there is no expectation for this regression; the coefficient estimate is negative, but economically and statistically insignificant. The negative and statistically significant coefficient estimate for adjacency for FDI is plausible because adjacent markets are more likely to be served by trade rather than horizontal FDI. Finally, the coefficient estimates for the language dummy in each regression have plausible signs and are economically and statistically significant.

C. Robustness Analysis

We have conducted numerous robustness analyses. For brevity, we report only three to confirm that our results are robust. First, because outward FDI stocks often are zero, the results provided in Table 3 for FDI exclude zeros. Santos Silva and Tenreyro (2006) showed that a Poisson Quasi-Maximum-Likelihood (PQML) estimator may avoid the bias associated with heteroskedasticity associated with Jensen’s inequality. Moreover, the technique also allows a natural way for including zeros on the LHS, a problem for the FDI variable as noted. Table 4 provides the results from re-estimating all three models in Table 3 using the PQML estimator instead; note that the inclusion of zeros has enlarged the FDI sample. The results for all the variables’s coefficient estimates are robust to this alternative estimation procedure, with adjacency now having a statistically significant effect on intermediates.

Second, the bilateral trade- and investment-cost variables included may not represent all such potential costs. Gravity equation analyses have often replaced specific bilateral variables with country-pair fixed effects. Table 5 presents the results of applying country-pair-specific $(ij)$ fixed effects, which eliminates the “Other control variables” in Table 3. We note that once again our coefficient estimates are robust to using country-pair fixed effects, with the exception that FDI’s coefficient estimate for investment costs becomes statistically insignificant.

Third, we were curious to see how well the gravity equation for intermediates trade (as well as for final goods trade and FDI) held up for a sample of countries outside the OECD. One might expect that the gravity equation (and Ethier-type intermediates trade) would not explain the variation in developing countries’ intermediates trade that well. Interestingly, the gravity equation works well also for the sample of non-OECD countries; see Table 6. Not surprisingly, the $R^2$ values are all lower than those for the OECD countries in Table 3, but they fall at most by 20 percent – and that was for final goods trade. For intermediates trade, the $R^2$ is only 10 percent less than for the OECD countries. Also, the coefficient estimates are similar. And where they differ, it can be explained readily. For instance, in Table 3 the coefficient estimate for Adjacency was negative (positive) and statistically significant.
This effect has also been referred to as the “pro-competitive” effect.

VII. Explaining the Growth of FDI Relative to Trade with Outsourcing

Markusen (2002), Barba Navaretti and Vanables (2004), Blonigen (2005), and Helpman (2006) all cite the growth of FDI relative to trade as one of the important stylized facts of international economics in the last two decades. However, our data on bilateral final and intermediates trade flows in section II suggests that the most rapid growth in FDI relative to trade has been among developed economies. The growth rate of FDI relative to trade among OECD countries in the 1990s was three to four times faster than that of OECD (non-OECD) to non-OECD (OECD) countries. Moreover, the ratio of FDI relative to trade actually declined among developing economies.

What economic factors potentially explain the rapid growth in FDI-to-trade among OECD countries? Four sources come to mind. First, the ratio of FDI-to-trade may grow over time if FDI barriers (i.e., investment costs) fall relative to trade barriers over time. Given our time-varying data on investment and trade costs discussed earlier, this proposition can be evaluated empirically. Our empirical model will include time-varying investment and trade costs.

Second, Markusen (2002, Ch. 5) argued in his Knowledge-Capital model with an oligopolistic market structure that a rise in economic size in both countries (i and j) could lead to an increase in FDI relative to trade. Under oligopoly, a rise in economic size leads to “firm-scale” effects (p. 83). For given trade and investment costs under oligopoly, an increase in both countries’ economic sizes increases MNEs’ markup revenues relative to NEs’ markup revenues, causing a rise in the equilibrium level of MNEs relative to NEs and a consequent increase in FDI-to-trade.29 This hypothesis is potentially testable since we can include time-varying GDPs in our empirical specification for FDI-to-trade.

A third possible explanation, and central to this paper, addresses the role of intermediates and fragmentation of the production process. A possible explanation for the growth of FDI-to-trade is the growth of intermediates trade. The denominator of the FDI-to-trade ratio, of course, includes both final and intermediates trade; hence, intuitively, growth of intermediates trade should tend to reduce FDI-to-trade over time through this simple channel. However, an economic channel through which intermediates trade works to increase FDI-to-trade is the following. In our theoretical model, national firms have one headquarters and one plant, while horizontal MNEs have one headquarters

29 This effect has also been referred to as the “pro-competitive” effect.
and multiple plants. The presence of outsourcing in our model—intermediate goods produced by domestic and foreign national firms and sold to final goods NEs and HMNEs using arm’s-length transactions—allows for further specialization of production of the type suggested in Ethier (1982), if market size is sufficiently large. Recent empirical analyses (formulated based upon Ethier-type intermediates) provide strong evidence that plants that import a larger share of intermediates are more productive, with two-thirds of the higher productivity attributable to “increased variety” of the Ethier-type, cf., Halpern et al. (2006). Since intermediates are sold directly to plants owned by either final-goods-producing NEs or HMNEs, multi-plant HMNEs benefit relatively more than single-plant (final-goods-producing) NEs from outsourcing since—if intermediates trade flows follow a “gravity relationship” (which section VI just showed)—HMNEs can economize on intermediates transport costs (relative to NEs) because of HMNEs’ “geographically-fragmented” plant structure (relative to NEs). Hence, in the presence of “outsourcing,” growth of intermediates trade should cause growth in the ratio of FDI relative to final goods trade. This hypothesis is potentially testable as we can include time-varying intermediates trade (specifically, an instrumental variable for this).

A fourth possible explanation for the growth of FDI-to-trade is an increase in “merger-and-acquisition” (M&A) FDI, rather than the “greenfield” type of FDI addressed in our knowledge-and-physical-capital model. There is considerable empirical evidence that M&A FDI activity increased substantively during the 1990s. However, this potential source of FDI growth is simply outside the scope of both our theoretical model and our empirical work. Consequently, this possible explanation is left for future research.

This section addresses theoretically and empirically the growth of FDI-to-trade. In section A, we consider two alternative scenarios of our numerical general equilibrium model: with and without the presence of intermediates production. We show theoretically that the presence of intermediates production and international outsourcing increases the ratio of FDI-to-trade. Since the analytical complexity of the model precludes closed-form solutions, we use our numerical GE model to simulate the comparative static results. In section B, we provide an econometric analysis of this effect. Since, as we have seen earlier that final goods trade, intermediate goods trade, and FDI are all driven by a “common process,” evaluating empirically the effect of intermediates trade on FDI relative to (final goods) trade is not a trivial econometric matter. However, we use instrumental variable estimation to account for endogeneity to evaluate our theoretical propositions. In section C, we provide a robustness analysis of our results.

A. Theory

30 These relationships also provide an economic explanation for the observed higher value added per worker of HMNEs relative to NEs in the MNE literature, cf., Bernard, Jensen, and Schott (2005).
Sections V and VI showed that final goods trade, intermediate goods trade, and FDI flows can be “well approximated” by the gravity equation. In the context of the theoretical model with a numerical application to OECD economies, such flows are seemingly determined *contemporaneously* by “common factors,” notably, absolute factor endowments, trade costs, and investment costs. The empirical analysis in section VI confirmed strongly four of five propositions suggested by the numerical GE model. R² values for the specifications of final goods trade and intermediate goods trade were over 80 percent; the R² value for the FDI gravity equation was 66 percent.

Given these theoretical and empirical results, we are now in position to understand better the potential role of intermediates outsourcing for explaining the behavior of FDI *relative to* trade over the period of the 1990s. First, our numerical GE model is capable of simulating the level of the bilateral FDI, final goods trade, and intermediates flows from i to j and the ratio of these flows (FDI/trade) *with* or *without* intermediates production and trade. In other words, our model can generate the *general-equilibrium* comparative-static effect of the introduction of a second production stage (intermediates) and international outsourcing of intermediates on the ratio of FDI to trade.

Figure 3a illustrates the general-equilibrium comparative-static effects. Figure 3a shows the comparative-static effects on bilateral outward FDI relative to bilateral final goods trade from i to j at various degrees of economic similarity of countries i and j. The economic rationale for the intermediates production and trade increasing the ratio is that, in the presence of Ethier-type intermediates specialization, horizontal MNEs’ profitability benefits more from the existence of specialization in intermediates in production and intermediates trade due to their multi-plant structure compared to single-plant final goods exporters’ profitability. The differential effect of introducing intermediates specialization and trade on the profitability of (say) a 3-country HMNE in country i relative to an NE in i is determined by the effect on \( \sum_{j=1}^{k} (p_{Xj} - c_{Xj}) x_{ij} \) for an HMNE versus \( (p_{Xi} - c_{Xi}) \sum_{j=1}^{k} x_{ij} \) for an NE (which cannot be derived analytically). These two terms reflect the importance of geographic fragmentation of plants in the relative cost structures of the two firm “types” and consequently provide a potential economic explanation for higher value added per worker (lower firm-wide marginal production costs) of HMNEs versus NEs.

The economic intuition can be seen most easily once again by starting at the far RHS of Figure 3a, when j’s GDP is small relative to i’s. When j’s GDP is small, j’s relatively small final goods consumer market is most profitably served from i by final goods NEs and some domestic production in j. At some point, as i’s GDP share gets smaller (due to an exogenous reallocation of factor endowments), it becomes more profitable from i to serve j’s final goods market using HMNEs based in i, and the number of NEs in i declines. However, Figure 3a shows that the increase in HMNE activity relative to NE activity in i is greater *with intermediates* in production than without them. The reason lies in Ethier-type intermediates specialization, cf., equation (8). Once final-goods-producing HMNEs headquartered in i incur the fixed cost of setting up plants in j and ROW (in the case of 3-country HMNEs), these firms also benefit from a (transport) cost reduction vis-à-vis NEs based in i with a single plant in i that must bear more
Simulations confirm that this effect dominates the relative advantage of NEs of larger plant output due to economies of scale in production (which tends to increase outsourcing). Consequently, the fragmentation of the production process combined with international outsourcing offers one economic explanation for the observed higher value added per worker (or “productivity”) of MNEs relative to NEs addressed in the recent MNE literature, cf., Bernard, Jensen, and Schott (2005). Moreover, for this channel to work, a key consideration is that the pattern of intermediates specialization is of the “Ethier-type.” But if it is, then bilateral intermediates trade flows should be explained by a “gravity relationship” – which is precisely what the empirical results in section VI showed.

While Figure 3a provides an unambiguous prediction about the effect of intermediates production on the ratio of FDI to final goods trade, a subtler prediction also surfaces from Figure 3a. This figure suggests that the ratio of FDI to trade will tend to be maximized when i’s (j’s) share of the two countries’ GDPs is larger (smaller) than j’s (i’s) share. This may tend to cause the coefficient estimate for GDP of country i (j) to be positive (negative).

Moreover, because we have a numerical GE model, we can even provide a quantitative prediction of the introduction of outsourcing on our model economy. Using Figure 3a, for a range of i’s share of both countries GDPs between 0.25 and 0.75, the introduction of intermediates production predicts an increase in the sum of FDI flows relative to the sum of trade flows between i and j from (approximately) 0.01 to 0.02. At i’s share of GDPs of 0.5 in Figure 3a, the ratio of gross flows increases by 60 percent from 0.020 to 0.032.

B. Main Empirical Results

While a numerical GE model can allow the calculation of general-equilibrium comparative statics, the real world is not so generous as to provide the conditions to “test” such a hypothesis. Nevertheless, it would be useful to see if one can explain even part of the variation in bilateral FDI-to-final-goods-trade ratios using an econometric model. However, our earlier results indicated that intermediates trade flows are determined simultaneously with final goods trade and FDI flows. So how would one evaluate econometrically the “effect” of (endogenous) intermediates trade flows on the flows of FDI relative to trade?

31Simulations confirm that this effect dominates the relative advantage of NEs of larger plant output due to economies of scale in production (which tends to increase outsourcing). We also note that the relative benefit to HMNEs’ productivity is enhanced the larger is ROW because the latter is relatively abundant in unskilled labor, which is used relatively intensively in production of intermediates. However, unskilled labor abundance of ROW is not necessary for HMNEs’ relative benefit.

32It can easily be shown that, in a gravity equation with equal coefficient estimates for exporter and importer GDPs, the flow will be maximized when the countries are identically sized. However, if the exporter (or home) GDP elasticity exceeds the importer (or host) GDP elasticity, such as for gross FDI flows, then the flow will be maximized when i’s share of their two GDPs is larger than j’s share, such as in theoretical Figure 1d or empirical Figure 2c. However, for the ratio of FDI to final goods trade from i to j, the ratio will be maximized when i’s share is of the two GDPs is larger than j’s share if i’s (j’s) GDP elasticity is positive (negative). To see this in a simple example, suppose $\text{Trade}_{ij} = \alpha \text{GDP}_i \text{GDP}_j$ and suppose $\text{FDI}_{ij} = \beta \text{GDP}_i^{1.2} \text{GDP}_j^{0.8}$ (as in Table 3). Then, $\frac{\text{FDI}_{ij}}{\text{Trade}_{ij}} = \frac{(\alpha/\beta) \text{GDP}_i^{0.2} \text{GDP}_j^{-0.2}}$
The approach that comes immediately to mind is the use of an instrumental variable (IV) technique. This is the approach we adopt. The first stage of an IV approach is to find a good “instrument” for intermediate goods trade flows (i.e., a variable correlated well with intermediates trade flows) that is also uncorrelated with the error terms in the second-stage (final goods trade and FDI) regressions. The obvious choice for the RHS variable in the first-stage regression is intermediate goods bilateral trade costs. We know from Table 3 that this variable is highly correlated with intermediate goods trade flows (hence, a “good” instrument), but is likely uncorrelated with the second-stage error terms (because the primary economic channel through which intermediates trade costs affect FDI and final goods trade is their direct effect on intermediate goods trade).

The second and third columns in Table 7 report the main empirical results from two-stage least-squares (2SLS) regressions using our unique pooled cross-section time-series data set for the OECD countries using only time dummies. The second (third) column reports the coefficient estimates (standard errors) from both stages. The first-stage results (reported just above the summary statistics) reveal that the intermediate goods trade cost variable is an excellent instrument for predicting intermediate goods trade flows.33 The top part of these two columns report the coefficient estimates from the second-stage regression of (the log of) the ratio of bilateral FDI to bilateral final goods exports from \(i\) to \(j\). We note several interesting findings. First, and most importantly, (instrumented) intermediate goods trade from \(i\) to \(j\) has a positive and statistically and economically significant effect on the ratio of FDI to final goods trade, confirming our hypothesis; a 100 percent increase in intermediate goods trade from \(i\) to \(j\) tends to increase the FDI/final goods trade ratio by about 46 percent. Second, although the coefficient estimate for exporter \(i\)’s GDP is economically and statistically insignificant, the coefficient estimate for importer \(j\)’s GDP is negative and statistically significant. This is consistent with the theoretical prediction in Figure 3a that the ratio of FDI to final goods trade will be maximized when \(i\)’s (\(j\)’s) share of the two countries’ GDPs is larger (smaller) than \(j\)’s (\(i\)’s) share. However, a negative coefficient estimate for importer’s GDP is inconsistent with the “firm-scale” effect associated with an oligopolistic market structure (cf., Markusen, p. 83). Third, investment (final goods trade) costs have a negative (positive) and economically and statistically significant effects on the ratio of FDI to final goods trade, as expected; these are own price effects. Fourth, while distance has no statistically significant relationship to this ratio, the ratio is negatively and economically and statistically significantly related to two countries’ sharing a common land border (Adjacency). This makes economic sense because two adjacent countries should have very low trade costs, decreasing the relative price of goods trade versus horizontal FDI, tending to lower the ratio of FDI to final goods trade. Finally, having a common language apparently lowers the relative cost of investment to trade, increasing the

---
33 Because we are limited to a single instrumental variable, we cannot conduct an “overidentifying restrictions” test of whether the residuals from the second stage regression are uncorrelated with the instrument.
ratio of FDI to final goods trade. The predicted empirical ratios of FDI to final goods trade with and without intermediates production are provided in Figure 3b.

C. Robustness Analysis

We have conducted numerous sensitivity analyses of the empirical findings. However, in the interest of brevity we report only three notable results. First, to preclude any omitted variables bias, we also estimated the model with two alternative specifications using fixed effects. Because the time-invariant “other control variables” listed in the first column may not exhaust all the possible time-invariant variables, we replaced them with country-pair-specific \((ij)\) dummy variables. The fourth and fifth columns in Table 7 report the coefficient estimates and standard errors, respectively, for (instrumented) intermediate goods trade flows, GDPs, and final goods trade and investment costs (and summary statistics; dummy coefficient estimates are omitted for brevity). We note that the results are robust to this alternative fixed-effects specification. The coefficient estimate for intermediates trade flows of 0.28 is positive, economically significant, and statistically significant. Also, the coefficient estimate for exporter \(i\)’s (importer \(j\)’s) GDP is positive (negative) and statistically significant. This confirms the comparative-static effect in Figure 3a that the ratio of FDI to final goods trade from \(i\) to \(j\) should be maximized when country \(i\)’s (\(j\)’s) share of the two countries’ GDPs is larger than \(j\)’s (\(i\)’s) share. Also, time-varying final goods trade costs and investment costs retain their theoretically predicted coefficient signs (and trade costs’ coefficient estimate is statistically significant).

Second, recent developments in the theoretical foundations for the gravity equation have emphasized the importance of recognizing time-varying “multilateral resistance” terms, cf., Anderson and van Wincoop (2003), Baier and Bergstrand (2007), and Bergstrand, Egger, and Larch (2007). To capture the influence of these terms, we use country-by-time \((it, jt)\) fixed effects, which then eliminate including exporter and importer GDPs and the (multilateral) investment cost index. This leaves a specification including (instrumented) intermediate goods trade flows, bilateral final goods trade costs, and the dummy variables just described on the RHS. The last two columns in Table 7 report the coefficient estimates and standard errors, respectively, for (instrumented) intermediate goods trade flows and final goods trade costs (and summary statistics; dummy coefficient estimates are omitted for brevity). We note that the results are robust to this alternative fixed-effects specification. The coefficient estimate for intermediates trade flows of 0.20 is positive, economically significant, and statistically significant.

Third, our data analysis in section II revealed that the vast bulk of growth of world FDI relative to world trade could be explained by the growth of intra-OECD FDI relative to intra-OECD trade. Our theoretical model suggested that this could be explained by the growth of international outsourcing of intermediates because the multi-plant structure of horizontal MNEs benefits more from specialization of intermediates compared with the single-plant structure of national final goods exporting firms. Indeed, the growth of vertical FDI relative to trade has been tamer.
in the 1990s, as the data in Table 1 reveals. A interesting test of the robustness of our results is that the ratio of FDI relative to trade outside the OECD should not be explained by outsourcing since – in the context of our model – vertical MNEs have only one plant, just like national final goods exporting firms. With single-plant structures in each, FDI relative to final goods trade growth should not be associated with intermediates production and trade. We have also run the same set of fixed-effect regressions as in Table 7, but using instead for our sample FDI, final goods trade, and intermediates good trade flows outside the OECD countries. For brevity, we do not report the results in a table; however, we discuss them briefly. For either fixed-effect regression for the ratio, the coefficient estimate for (instrumented) intermediates trade is negative, but economically and statistically insignificant from zero. For instance, in the fixed-effects regression with $ij$, $it$, and $jt$ effects, the intermediates trade coefficient estimate is -0.06 with a standard error of 0.16. Thus, where we do not expect intermediates trade to affect the ratio of FDI to final goods trade, intermediates trade does not affect this ratio.\footnote{We have also run sensitivity analyses using Poisson Quasi-Maximum-Likelihood (PQML) estimation techniques and various other specifications and the results in our paper are robust. These are not reported for brevity, but are available on request.}

**VIII. Conclusions**

We note three potential contributions of our study. First, we have constructed from 5-digit SITC bilateral trade flows among 160 countries the most comprehensive bilateral trade flow data set decomposed into final goods and intermediate goods trade flows. Among numerous insights, the data set revealed that the vast bulk of growth of world FDI relative to world trade has been driven by the growth in this ratio among similar, rich OECD countries. Second, developing a Knowledge-and-Physical-Capital model of multinationals including a second production stage (intermediates) and calibrating it numerically, we formulated a theoretical rationale for estimating (simultaneously) gravity equations for bilateral final goods trade flows, bilateral intermediate goods trade flows, and bilateral outward FDI flows. We showed that the predicted theoretical final goods trade, intermediate goods trade, and FDI flows from $i$ to $j$ from the model explained very well the predicted empirical final goods trade, intermediate goods trade, and FDI flows from $i$ to $j$. Third, we showed theoretically and empirically that international outsourcing of intermediates production could explain an economically significant amount of the level of FDI relative to final goods trade. Finally, we noted in our sample that for the OECD countries the ratio of FDI to final goods trade grew by 125 percent from 1990-2000. Final goods trade grew about 54 percent, and intermediate goods trade grew by 48 percent. Using our coefficient estimate of 0.46 from the pooled cross-section time-series estimation of Table 3, the 48 percent growth of intra-OECD intermediates trade growth explains 22 percent of the 125 percent growth of FDI relative to final goods trade of the sample ($0.46 \times 48 = 22$), or roughly one-fifth of the increase in FDI relative to final goods trade.
References


### Table 1a

<table>
<thead>
<tr>
<th></th>
<th>Total goods exports</th>
<th>Outward FDI stocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exporters</td>
<td>Importers</td>
</tr>
<tr>
<td></td>
<td>OECD</td>
<td>Non-OECD</td>
</tr>
<tr>
<td>OECD</td>
<td>55.56</td>
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</tr>
<tr>
<td>Non-OECD</td>
<td>14.69</td>
<td>9.86</td>
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<table>
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<tr>
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<th>Final goods exports</th>
<th>Intermediate goods exports</th>
</tr>
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<tbody>
<tr>
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<td>Importers</td>
</tr>
<tr>
<td>OECD</td>
<td>56.12</td>
<td>18.37</td>
</tr>
<tr>
<td>Non-OECD</td>
<td>16.72</td>
<td>8.79</td>
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### Table 1b

<table>
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<th>Total goods exports</th>
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<td>OECD</td>
<td>4.21</td>
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<td>Non-OECD</td>
<td>15.22</td>
<td>19.25</td>
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<table>
<thead>
<tr>
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<th>Final goods exports</th>
<th>Intermediate goods exports</th>
</tr>
</thead>
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<tr>
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<td>Importers</td>
</tr>
<tr>
<td>OECD</td>
<td>4.41</td>
<td>6.98</td>
</tr>
<tr>
<td>Non-OECD</td>
<td>14.57</td>
<td>18.46</td>
</tr>
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</table>

Note: There are 24 OECD and 136 Non-OECD countries in the data. Intermediate goods exports account for about 46 percent of total exports in the data (old OECD definition see the Appendix). FDI figures are based on data from the OECD (Foreign Direct Investment Statistics Yearbook 2006) and UNCTAD (Major FDI Indicators; World Investment Report 2007).
<table>
<thead>
<tr>
<th>Broad Economic Categories, Revision 3, code</th>
<th>Number of SITC 5-digit lines covered</th>
<th>Of which classified as intermediates</th>
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<tbody>
<tr>
<td>1 - Food and beverages</td>
<td>372</td>
<td>113</td>
</tr>
<tr>
<td>11 - Primary</td>
<td>140</td>
<td>44</td>
</tr>
<tr>
<td>111 - Mainly for industry</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td>112 - Mainly for household consumption</td>
<td>96</td>
<td>0</td>
</tr>
<tr>
<td>12 - Processed</td>
<td>232</td>
<td>69</td>
</tr>
<tr>
<td>121 - Mainly for industry</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>122 - Mainly for household consumption</td>
<td>163</td>
<td>0</td>
</tr>
<tr>
<td>2 - Industrial supplies not elsewhere specified</td>
<td>1526</td>
<td>1107</td>
</tr>
<tr>
<td>21 - Primary</td>
<td>228</td>
<td>228</td>
</tr>
<tr>
<td>22 - Processed</td>
<td>1298</td>
<td>879</td>
</tr>
<tr>
<td>3 - Fuels and lubricants</td>
<td>32</td>
<td>9</td>
</tr>
<tr>
<td>31 - Primary</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>32 - Processed</td>
<td>23</td>
<td>0</td>
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<td>321 - Motor spirit</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>322 - Other</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>4 - Capital goods (except transport equipment), and parts and accessories thereof</td>
<td>637</td>
<td>273</td>
</tr>
<tr>
<td>41 - Capital goods (except transport equipment)</td>
<td>435</td>
<td>71</td>
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<tr>
<td>42 - Parts and accessories</td>
<td>202</td>
<td>202</td>
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<tr>
<td>5 - Transport equipment and parts and accessories thereof</td>
<td>112</td>
<td>58</td>
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<tr>
<td>51 - Passenger motor cars</td>
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<td>0</td>
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<tr>
<td>52 - Other</td>
<td>53</td>
<td>0</td>
</tr>
<tr>
<td>53 - Parts and accessories</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>6 - Consumer goods not elsewhere specified</td>
<td>428</td>
<td>0</td>
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<tr>
<td>61 - Durable</td>
<td>96</td>
<td>0</td>
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<tr>
<td>62 - Semi-durable</td>
<td>208</td>
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<tr>
<td>63 - Non-durable</td>
<td>124</td>
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</tr>
<tr>
<td>7 - Goods not elsewhere specified</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>3121</td>
<td>1560</td>
</tr>
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</table>

Notes: Source is the United Nations’ Statistics Division. Intermediate goods categories in grey. If part of the 'processed' categories appearing in grey had been classified as intermediate goods, these categories appear as dotted areas. For instance, this is the case for SITC categories under division 081 which collect ‘Feeding stuff for animals (not including unmilled cereals)’ or under division 26 ‘Textile fibres and their wastes’. The total number of headings classified as intermediate goods is 1560. The remaining categories are final goods.
Table 3
Bilateral Flows of Final and Intermediate Goods Exports and Bilateral Stocks of Outward FDI within the OECD (1990-2000)

<table>
<thead>
<tr>
<th></th>
<th>Final goods exports $_{ijt}$</th>
<th>Intermediate goods exports $_{ijt}$</th>
<th>Outward FDI stocks $_{ijt}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>log GDP $_{it}$</td>
<td>0.835</td>
<td>0.952</td>
<td>1.164</td>
</tr>
<tr>
<td></td>
<td>0.025 $^b$</td>
<td>0.031 $^b$</td>
<td>0.044 $^b$</td>
</tr>
<tr>
<td>log GDP $_{jt}$</td>
<td>0.794</td>
<td>0.799</td>
<td>0.809</td>
</tr>
<tr>
<td></td>
<td>0.027 $^b$</td>
<td>0.031 $^b$</td>
<td>0.062 $^b$</td>
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<tr>
<td>Log final goods trade costs $_{ijt}$</td>
<td>-0.785</td>
<td>-0.196</td>
<td>-0.237</td>
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<tr>
<td></td>
<td>0.148 $^b$</td>
<td>0.119</td>
<td>0.254</td>
</tr>
<tr>
<td>Log intermediate goods trade costs $_{ijt}$</td>
<td>-0.124</td>
<td>-0.849</td>
<td>-0.425</td>
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<tr>
<td></td>
<td>0.089</td>
<td>0.104 $^b$</td>
<td>0.179 $^a$</td>
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<tr>
<td>Log investment costs $_{jt}$</td>
<td>0.025</td>
<td>-0.021</td>
<td>-0.621</td>
</tr>
<tr>
<td></td>
<td>0.111</td>
<td>0.137</td>
<td>0.261 $^a$</td>
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Other control variables:

<table>
<thead>
<tr>
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<th>Intermediate goods exports $_{ijt}$</th>
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<tr>
<td>Log Distance $_{ij}$</td>
<td>-0.719</td>
<td>-0.958</td>
<td>-0.826</td>
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<tr>
<td></td>
<td>0.037 $^b$</td>
<td>0.044 $^b$</td>
<td>0.084 $^b$</td>
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<td>Adjacency $_{ij}$</td>
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<td>-0.056</td>
<td>-0.665</td>
</tr>
<tr>
<td></td>
<td>0.141</td>
<td>0.150</td>
<td>0.314 $^a$</td>
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<tr>
<td>Language $_{ij}$</td>
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<td>0.789</td>
<td>1.955</td>
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<tr>
<td></td>
<td>0.122 $^b$</td>
<td>0.120 $^b$</td>
<td>0.232 $^b$</td>
</tr>
</tbody>
</table>

Time dummies                 yes                                                                 yes
Number of observations       5328                                                                 5328               2731
R$^2$                       0.850                                                                 0.815               0.660
Root MSE                    0.799                                                                 1.040               1.630

Notes: Reported coefficients and standard errors are pooled OLS estimates. Standard errors are robust to heteroskedasticity and clustering at the country-pair level. Superscripts a and b refer to significance levels of 5 and 1 percent, respectively.
Table 4

<table>
<thead>
<tr>
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<th>Intermediate goods exports_{ijt}</th>
<th>Outward FDI stocks_{ijt}</th>
</tr>
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<tbody>
<tr>
<td>log GDP_{it}</td>
<td>0.783</td>
<td>0.038 c</td>
<td>0.801</td>
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<tr>
<td>log GDP_{jt}</td>
<td>0.803</td>
<td>0.046 c</td>
<td>0.786</td>
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<tr>
<td>Log final goods trade costs_{ijt}</td>
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<tr>
<td>Log intermediate goods trade costs_{ijt}</td>
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<td>Number of observations</td>
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<td>5328</td>
<td>3439</td>
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<tr>
<td>Log pseudo-likelihood</td>
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<td>-1432.95</td>
<td>-6091.52</td>
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</tbody>
</table>

Notes: Reported coefficients and standard errors are pooled Poisson QMLE estimates. Standard errors are robust to heteroskedasticity and clustering at the country-pair level. Superscripts a, b, and c refer to significance levels of 10, 5, and 1 percent, respectively.
Table 5

<table>
<thead>
<tr>
<th>Dependent variable is log of:</th>
<th>Final goods exports$_{ijt}$</th>
<th>Intermediate goods exports$_{ijt}$</th>
<th>Outward FDI stocks$_{it}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>log GDP$_{jt}$</td>
<td>0.125 0.042 $^c$</td>
<td>0.170 0.096 $^a$</td>
<td>0.307 0.171 $^a$</td>
</tr>
<tr>
<td>log GDP$_{jt}$</td>
<td>0.809 0.043 $^c$</td>
<td>0.571 0.096 $^c$</td>
<td>0.609 0.146 $^c$</td>
</tr>
<tr>
<td>Log final goods trade costs$_{ijt}$</td>
<td>-0.474 0.018 $^c$</td>
<td>0.034 0.041</td>
<td>-0.107 0.070</td>
</tr>
<tr>
<td>Log intermediate goods trade costs$_{ijt}$</td>
<td>0.013 0.014</td>
<td>-0.732 0.031 $^c$</td>
<td>-0.171 0.059 $^c$</td>
</tr>
<tr>
<td>Log investment costs$_{jt}$</td>
<td>0.004 0.036</td>
<td>-0.085 0.080</td>
<td>-0.088 0.116</td>
</tr>
</tbody>
</table>

Other control variables:
- Time dummies: yes, yes, yes
- Number of observations: 5328, 5328, 2731
- Within R$^2$: 0.460, 0.201, 0.307
- Root MSE: 0.258, 0.583, 0.566

Notes: Reported coefficients and standard errors are pooled OLS estimates. Standard errors are robust to heteroskedasticity and clustering at the country-pair level. Superscripts a, b, and c refer to significance levels of 10, 5, and 1 percent, respectively.
Table 6

<table>
<thead>
<tr>
<th></th>
<th>Final goods exports_{ijt}</th>
<th>Intermediate goods exports_{ijt}</th>
<th>Outward FDI stocks_{ijt}</th>
</tr>
</thead>
<tbody>
<tr>
<td>log GDP_{it}</td>
<td>1.143 0.015 (^c)</td>
<td>1.392 0.016 (^c)</td>
<td>1.403 0.083 (^c)</td>
</tr>
<tr>
<td>log GDP_{jt}</td>
<td>0.984 0.022 (^c)</td>
<td>0.855 0.025 (^c)</td>
<td>0.384 0.125 (^c)</td>
</tr>
<tr>
<td>Log final goods trade costs_{ijt}</td>
<td>-0.650 0.018 (^c)</td>
<td>-0.116 0.019 (^c)</td>
<td>0.342 0.203 (^a)</td>
</tr>
<tr>
<td>Log intermediate goods trade costs_{ijt}</td>
<td>-0.040 0.015 (^c)</td>
<td>-0.699 0.017 (^c)</td>
<td>0.644 0.206 (^c)</td>
</tr>
<tr>
<td>Log investment costs_{jt}</td>
<td>-0.735 0.074 (^c)</td>
<td>-0.072 0.084</td>
<td>-0.714 0.304 (^b)</td>
</tr>
<tr>
<td>Other control variables:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Distance_{ij}</td>
<td>-0.831 0.033 (^c)</td>
<td>-1.083 0.037 (^c)</td>
<td>0.311 0.181 (^a)</td>
</tr>
<tr>
<td>Adjacency_{ij}</td>
<td>0.937 0.179 (^c)</td>
<td>0.784 0.183 (^c)</td>
<td>1.156 0.421 (^c)</td>
</tr>
<tr>
<td>Language_{ij}</td>
<td>0.931 0.077 (^c)</td>
<td>1.031 0.094 (^c)</td>
<td>1.081 0.403 (^c)</td>
</tr>
<tr>
<td>Time dummies</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Number of observations</td>
<td>22103</td>
<td>22103</td>
<td>1686</td>
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<tr>
<td>R(^2)</td>
<td>0.678</td>
<td>0.708</td>
<td>0.513</td>
</tr>
<tr>
<td>Root MSE</td>
<td>1.649</td>
<td>1.810</td>
<td>1.898</td>
</tr>
</tbody>
</table>

Notes: Reported coefficients and standard errors are pooled OLS estimates. Standard errors are robust to heteroskedasticity and clustering at the country-pair level. Superscripts a, b, and c refer to significance levels of 10, 5, and 1 percent, respectively.
### Table 7

Interconnectedness of Bilateral FDI, Final Goods Exports, and Intermediate Goods Exports within the OECD (1990-2000)

| Dependent variable is log of $\text{FDI}_{it}$ / $\text{Final Goods Exports}_{it}$ |
|---|---|---|---|---|---|---|
| Log intermediate goods exports$_{it}$ | 0.461 | 0.182 $^a$ | 0.283 | 0.079 $^b$ | 0.203 | 0.081 $^b$ |
| log GDP$_{it}$ | 0.008 | 0.170 | 2.397 | 0.497 $^b$ | - | - |
| log GDP$_{jt}$ | -0.303 | 0.149 $^a$ | -1.305 | 0.366 $^b$ | - | - |
| Log final good trade costs$_{it}$ | 0.607 | 0.237 $^a$ | 0.387 | 0.076 $^b$ | 0.411 | 0.077 $^b$ |
| Log investment costs$_{jt}$ | -0.541 | 0.221 $^a$ | -0.087 | 0.125 | - | - |

Other control variables:

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Log Distance$_{ij}$</td>
<td>0.210</td>
<td>0.179</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>Adjacency$_{ij}$</td>
<td>-1.112</td>
<td>0.231 $^b$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Language$_{ij}$</td>
<td>1.284</td>
<td>0.212 $^b$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Time dummies</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Country-pair dummies</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td></td>
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<tr>
<td>Exporter-time and importer-time dummies</td>
<td>no</td>
<td>no</td>
<td>yes</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

First stage model

<table>
<thead>
<tr>
<th>Log intermediate good trade costs$_{ijt}$</th>
<th>-0.893</th>
<th>0.060 $^b$</th>
<th>-0.805</th>
<th>0.078 $^b$</th>
<th>-0.795</th>
<th>0.027 $^b$</th>
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</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>2731</td>
<td>2731</td>
<td>2731</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Second stage model $R^2$</td>
<td>0.276</td>
<td>0.895</td>
<td>0.928</td>
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<tr>
<td>Root MSE in second stage model</td>
<td>1.496</td>
<td>0.611</td>
<td>0.546</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Reported coefficients and standard errors are pooled OLS estimates. Standard errors are robust to heteroskedasticity and clustering at the country-pair level. Superscripts a and b refer to significance levels of 5 and 1 percent, respectively.
Figure 1
Theoretical Flows of Final Goods and Intermediate Goods Nominal Exports and Nominal Outward FDI

Figure 1a: Gravity Equation Flow from i to j
Figure 1b: Final Goods Nominal Exports from i to j
Figure 1c: Intermediate Goods Nominal Exports from i to j
Figure 1d: Nominal FDI from i to j
Figure 2
Empirical (Intra-OECD) Flows of Final Goods and Intermediate Goods Nominal Exports and Nominal Outward FDI

Figure 2a: Intra-OECD Final Goods Nominal Exports from i to j

Figure 2b: Intra-OECD Intermediate Goods Nominal Exports from i to j

Figure 2c: Intra-OECD Nominal FDI from i to j
Figure 3
Ratio of Outward FDI to Final Goods Trade With/Without Intermediate Goods Production

Figure 3a: Theoretically-Predicted Ratio of Nominal Outward FDI to Final Goods Nominal Exports from i to j

Figure 3b: Empirically-Predicted Ratio of Nominal Outward FDI to Final Goods Nominal Exports from i to j
Appendix A

(NOT INTENDED FOR PUBLICATION)

We assume that, in equilibrium, all factors are fully employed for each country \(i\) \((i=1,2,3)\), so that:

\[
K_i \geq a_{Ki} \left[ n_i \sum_{j=1}^{3} x_{ij} + x_{ii} \left( \sum_{j=1}^{3} h_{3,j} + \sum_{j \neq i} h_{2,j} + \sum_{j \neq i} h_{2,j} \right) + \sum_{j \neq i} \gamma_{ij} \left( \sum_{j=1}^{3} x_{ij} \right) \right] + \\
a_{K_{ii}} \gamma_{ii} + a_{K_{ii}} \gamma_{ii} \left[ 3 + \sum_{j \neq i} \gamma_{ij} \right] h_{3,j} + [2 + \gamma_{ij}] h_{2,j} + [1 + \gamma_{ij}] v_{ij} \right] \\
S_i \geq a_{Si} \left[ n_i \sum_{j=1}^{3} x_{ij} + x_{ii} \left( \sum_{j=1}^{3} h_{3,j} + \sum_{j \neq i} h_{2,j} + \sum_{j \neq i} h_{2,j} \right) + \sum_{j \neq i} \gamma_{ij} \left( \sum_{j=1}^{3} x_{ij} \right) \right] + \\
a_{S_{ii}} \gamma_{ii} \sum_{j=1}^{3} z_{ij} + a_{S_{ii}} \gamma_{ii} \left( h_{3,j} + \sum_{j \neq i} (h_{2,j} + v_{ij}) \right) \\
U_i \geq a_{Ui} \left[ n_i \sum_{j=1}^{3} x_{ij} + x_{ii} \left( \sum_{j=1}^{3} h_{3,j} + \sum_{j \neq i} h_{2,j} + \sum_{j \neq i} h_{2,j} \right) + \sum_{j \neq i} \gamma_{ij} \left( \sum_{j=1}^{3} x_{ij} \right) \right] + \\
a_{U_{ii}} \gamma_{ii} \sum_{j=1}^{3} t_{ij} Y_{ij} + a_{U_{ii}} \gamma_{ii} \sum_{j=1}^{3} z_{ij} \\
\]

Multilateral current account balance for each country \(i\) \((i = 1, 2, 3)\) requires the following to hold:

\[
o_j p_{ij} (z_j + z_{ir}) + (n_i + v_{ji} + v_{ri}) p_{Xj} (x_{ij} + x_{ir}) + p_{Yj} Y_{ij} + p_{Yr} Y_{ir} + \\
+ \frac{1}{1 - \varepsilon} \left( [h_{2,ji} + h_{3,j}] p_{Xj} x_{ij} + [h_{2,ir} + h_{3,r}] p_{Xr} x_{ir} \right) \\
+ \frac{1}{1 - \varepsilon} \left( v_{ij} p_{Xj} [x_{ij} + x_{ir} + x_{jr}] + v_{ir} p_{Xr} [x_{ir} + x_{ri} + x_{jr}] \right) \]

\[
= o_j p_{ij} z_{ji} + o_j p_{Zj} z_{ri} + (n_j + v_{ij} + v_{jr}) p_{Xj} x_{ji} + (n_r + v_{ir} + v_{jr}) p_{Xr} x_{ri} + p_{Yj} (Y_{ji} + Y_{ri}) + \\
+ \frac{1}{1 - \varepsilon} (h_{2,ji} + h_{3,j} + h_{2,ir} + h_{3,r}) p_{Xj} x_{ji} \\
+ \frac{1}{1 - \varepsilon} (v_{ji} + v_{ri}) p_{Xj} (x_{ji} + x_{iq} + x_{ir}) \]

The first line in equation (A2) represents the exports of intermediate and final goods of country \(i\). The second and third lines represent income earned on capital invested by country \(i\) in horizontal and vertical affiliates, respectively, in country’s \(j\) and \(r\) (denoting the ROW). The fourth line represents country \(i\)’s imports of goods from \(j\) and \(r\). The fifth and sixth lines represent \(i\)’s repatriation of income on capital of countries’ \(j\) and \(r\) invested in country \(i\) in horizontal and vertical affiliates, respectively.