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Nonroutine Tasks in International Trade

A dissertation submitted in partial satisfaction of the
Requirements for the degree Doctor of Philosophy

in

Economics

by

Lindsay Oldenski

Committee in Charge:

Professor Gordon Hanson, Chair
Professor Arnaud Costinot
Professor Stephen Haggard
Professor Craig McIntosh
Professor James Rauch

2009

The dissertation of Lindsay Oldenski is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California, San Diego

2009

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ABSTRACT OF THE DISSERTATION

Nonroutine Tasks in International Trade

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Chapter 1 shows that standard predictors of the export versus FDI decision hold for manufacturing but not for service industries. I develop an alternative model which decomposes each industry into tasks and uses these tasks to predict the location of production for that industry. Industries requiring direct communication with consumers are more likely to be produced in the destination market. Production of more nonroutine activities is more likely to occur at the multinational's headquarters for export, especially when the destination market has weak contract-enforcing institutions. The task-based approach performs well for both manufacturing and services, has greater explanatory power than alternative models, and is robust to a variety of specifications.

Chapter 2 offers an empirical analysis of the impact of adaptation on the boundary of multinational firms. We first develop a ranking of sectors in terms of their "routineness" by merging ratings of occupations by their intensities in "problem solving" and U.S. employment shares of occupations by sectors. We then demonstrate that, in line with adaptation theories of the firm, the share of intrafirm trade tends to be higher

in less routine sectors. This result is robust to inclusion of other variables known to influence the intrafirm import share.

In chapter 3, I explore the extent to which horizontal exports and FDI by US multinationals are complements. I use host-country restrictions on capital investment in service industries that were in place in 1993 as an instrument for FDI flows in service industries for 1994 to 2004. I find that increased FDI flows in a given service industry by US multinationals significantly increase US exports in that industry to the country receiving those FDI flows. This holds for exports and FDI of final services as well as for overall FDI flows. I also present evidence that the complementarity between exports and FDI is stronger for service industries than it is for manufacturing by using the existence of bilateral investment treaties at the country level as an instrument and estimating the relationship on separate samples of manufacturing and services.

1 Export Versus FDI: A Task-Based Framework for Comparing Manufacturing and Services

1.1 Introduction

Manufacturing and service firms do not serve foreign markets in the same way. In manufacturing, exports and sales through FDI comprise roughly equal shares of total foreign sales by US multinationals. Yet service producers overwhelmingly rely on investment rather than exports (see Figure 1). In this paper, I show that standard predictors of the export versus FDI decision such as distance and market size cannot explain this difference across sectors. I augment the Helpman, Melitz and Yeaple (2004) model with the potential for imperfect contracts and miscommunication and propose a new set of measures that capture the relative cost of contracting out production to foreign affiliates through FDI or shipping final products cross-border through exports. This approach is significant for both manufacturing and service industries and can explain 40 percent of the difference in export to FDI ratios across the two sectors.

In the export versus FDI literature, the decision to produce at home for export or in the destination market through FDI is based on a tradeoff between the gains to scale achieved by concentrating production in the home country for export and the benefits of producing near the final consumers to avoid marginal transport costs. I show that this tradeoff, while robust for goods, is not a significant determinant of the export to FDI ratio in services. Instead, I use a measure of the relative costs of FDI and exporting that breaks industries down into an even finer level of detail: tasks. A task is a specific activity (such as making decisions, communicating with customers, operating machinery, etc.) that must be performed in the production of a given industry's output. Certain activities are more difficult to export across borders or to offshore to foreign affiliates for production. In particular, tasks requiring direct communication with consumers are more likely to be performed in the destination market where consumers are located. Communicating with customers is about twice as important for services as for manufacturing (see Table

1). I show that because services require much more interaction with consumers than manufactures, the difference in the importance of this task can explain much of the difference in export to FDI ratios across the two sectors. This relationship between the need for consumer interaction and higher relative FDI is highly intuitive but has never been shown in the economic literature on the export versus FDI decision.

If communicating with consumers were the only task that mattered for the export versus FDI decision, we would expect to see nearly all services provided through investment. Figure 1 shows that about 30 percent of sales of services to foreign markets are through exports. Controlling for standard determinants of trade and investment, I show that the level of complexity of production tasks has an effect that is opposite to that of communication intensity, offsetting some of the impact of the need for consumer interaction. More nonroutine activities are more difficult to completely contract for and thus their production is less likely to be offshored to foreign affiliates, especially if the foreign affiliate is in a country with weak contract enforcing institutions. I introduce a model of incomplete contracts into a Helpman, Meltiz and Yeaple framework to explain how the level of routineness of tasks determines how easily they can be offshored. Interactions of tasks with the contracting environment and language of the destination market capture country-industry level variation in these effects. Because more non-routine tasks require judgment, creativity, decision making, and otherwise do not follow explicitly defined rules (Autor, Levy and Murnane 2003) they are much more difficult to specify in complete contracts and thus offshoring the production of nonroutine tasks exposes the firm to a higher level of contracting risk. This risk is higher in countries with weak contract-enforcing institutions.

When each industry is defined by the series of tasks used in its production, the differences between manufactures and services become clear. On average, the importance of working with the public is twice as high for services as for manufactures. Scores for nonroutine tasks, such as creative thinking, are 44 percent higher. In general, manufacturing industries are comprised of relatively more manual and routine tasks, while

service production requires relatively more nonroutine, cognitive, and communication tasks. Table 1 summarizes the key task dimensions that I will use in this paper and Table 2 provides detail on a broader range of tasks. The data on these tasks that is collected by the Department of Labor allows for empirical identification of the role tasks play in determining patterns of trade and investment. The service industries used in this study are listed in Table 4. Business, professional and technical services make up most of the sample.

The results show that the task contracting model I propose is robust for both manufacturing and services, even after controlling for distance, market size, tax rates, education levels, and standard measures of endowment-based comparative advantage. The intensity with which an industry uses communication and nonroutine tasks is a significant determinant of the location of multinational production. The relationship between task intensity and the export to FDI ratio is similar for manufacturing and service industries, suggesting that the difference in task compositions across sectors presented in Table 1 can explain the difference in trade and investment outcomes presented in Figure 1. I decompose the difference in export-FDI ratios between the two sectors into the share attributable to the different characteristics of the sectors (X's) and the share attributable to the different relationships between these characteristics and the export to FDI ratio (coefficients). Of the total difference, 40 percent can be explained by the differential task characteristics across industries.

1.2 Related Literature

This paper is motivated by a broad literature on the organization of multinational activities. However, for the empirical exercise, I focus on one specific aspect of this organization: the decision to serve foreign markets through exports or FDI. When US firms sell goods to foreign consumers they have three options: (1) produce at home for export, (2) open up an affiliate in the destination market and produce locally, or (3) fragment production such that firm ownership, production, and consumption each occur in one or more different locations. Option (2) is broadly referred to as horizontal

FDI and option (3), which includes licensing, franchising and subcontracting, as vertical FDI. While evidence of both vertical and horizontal motives for FDI have been well documented (see for example, Krugman (1983), Helpman (1984), Markusen (1984), and Markusen and Maskus (2002)), focusing on the subset of horizontal FDI sales relative to exports of final goods allows for sharp predictions to be made about the determinants of trade relative to investment in final goods. Krugman (1983) developed a model in which firms trade off proximity to consumers (FDI) against the gains to scale achieved by concentrating production in one location for export. Brainard (1993 and 1997) refined this proximity-concentration model and found strong empirical support for its predictions. Helpman, Melitz, and Yeaple (2004) introduced firm-level heterogeneity and found that the impact of heterogeneity is similar in magnitude to that of the proximity-concentration effect.

Despite the growing importance of services in international trade (see Figure 1), nearly all empirical research focuses on trade in manufactures.¹ To my knowledge, no papers have examined the decision of service firms serve foreign markets through exports or FDI. This paucity of research on services trade would not be problematic if we could be certain that trade and investment in services were determined by the same factors as trade and investment in manufactures. However, Figure 1 suggests that this is not the case. This paper exploits those differences in the task composition of manufacturing and service industries to explain the different ways in which manufacturing and service firms serve foreign markets. The result is a framework that is robust for both manufacturing and services, and that can explain much of the difference in patterns of trade and investment across the two sectors.

1.3 Theoretical Framework

In this section, I present a model of horizontal FDI in which US multinationals trade off the costs of exporting and the costs of FDI when deciding how to serve foreign

¹See Freund and Weinhold (2002), Amiti and Wei (2005), Jensen and Kletzer (2005), or Hanson and Xiang (2008) for examples of research on international trade in services

markets. The basic framework follows a Helpman, Melitz and Yeaple (2004) model of heterogeneous firms. I extend Helpman, Melitz and Yeaple by explicitly modeling trade and investment costs through the use of task-based contracting.² Because tasks differ in their level of complexity, the potential for contract failure and miscommunication is a source of variation between country-industry pairs. This model generates predictions about how characteristics of the tasks embodied in each industry interacted with characteristics of the trading countries determine the extent of trade and investment costs, and thus the relative magnitudes of exports versus FDI. The task-based framework of this model is particularly useful for the study of trade and investment in services as well as goods.

This model begins with a continuum of goods and services producing industries, $z \in (0, 1)$. Each of these industries is comprised of a discrete number of tasks, $s \in (1, 2, \dots, S_z)$, which must be performed to produce the final good or service. The key characteristics of each industry can be represented by the specific tasks involved in producing the final good or service as well as the importance of each of these tasks in that industry. Tasks are defined by their specific characteristics (e.g. decision-making, communicating with customers, handling objects, etc.). Tasks can be performed anywhere, however, due to limitations on the nature of trade data, tasks can only be traded when they are bundled together as goods and services, z . Because each of the tasks, s , contained in z must be performed to complete the product, firms are modeled as having a Leontief production function

$$q(z) = \min[\alpha_{1z}s_1, \alpha_{2z}s_2, \dots, \alpha_{S_z}s_{S_z}] \quad (1)$$

where α_{sz} is the importance of each task in industry z and $q(z)$ is the output of z . Note that z can be either a final or intermediate good or service.

²Grossman and Rossi-Hansberg (2006) develop a model of trade in tasks in which production consists of a series of value-added tasks that can be performed in any location. My framework differs from theirs in that I focus on a horizontal FDI decision in which final products are produced at home or abroad according to their task characteristics, rather than a vertical model of the fragmentation of production tasks across countries

1.3.1 Costs Associated with Task Performance

The difference in task compositions across industries leads to differences in the costs of trade and FDI. Because US multinational headquarters decide whether to produce each good or service at home for export or offshore its production to a local affiliate, FDI can be conceived of as contracting out production to the destination market. Therefore the successful fulfillment of contractual obligations is a key component of FDI, and any risk that contractual obligations will not be completed raises the cost of FDI. Breakdowns in communication, both within firm and between the producer and the final consumer, are also costly. I model both of these types of costs: (1) costs relating to contract failure and (2) costs related to communication failure.

Under contract failure, a worker will fail to perform an assigned task if the cost of complying is greater than the cost of shirking. Because the cost of shirking is increasing in the likelihood that the contract will be enforced, shirking is less likely to occur in countries with stronger contract-enforcing institutions. Because routine tasks can be clearly described in writing (see Autor, Levy and Murnane (2003)), shirking is less likely to occur in industries with a greater share of routine to nonroutine tasks. Contracts are enforced with a probability of $e^{-\theta_{zi}}$ where $0 < \theta_{zi} < 1$ measures the quality of contracts in country i and industry z . Thus $e^{-\theta_{zi}}$ is the share of production expected to be completed successfully if the tasks embodied in z are performed in country i . θ_{zi} can be further decomposed into:

$$\theta_{zi} = \theta_z + \theta_i + (\theta_z * \theta_i) \quad (2)$$

θ_z captures the task-requirements of industry z , such as importance of nonroutine tasks, θ_i captures the country-specific contracting environment, and $(\theta_z * \theta_i)$ interacts country and task characteristics (e.g. contract enforcement institutions should be more important for relatively more nonroutine task-intensive industries). This specification is similar to

Kremer (1993) and Costinot (2008), except that in this case the success probability is a function of institutions and task intensities. Anderson and Marcouiller (2002), show that institutions matter for the likelihood that a shipment will reach its intended destination, functioning like an iceberg-style transport cost on exports. Acemoglu, Antras, and Helpman (2007) demonstrate that the quality of contracting institutions affects the level of investment in a Grossman Hart (1986) framework. I will allow for both of these roles of institutions (protecting shipments and enforcing contracts). Because the probability of contract failure is different for exporting than for FDI, let θ_{zi}^x denote the risk parameter for exporting and let θ_{zi}^I denote the risk parameter for FDI.

Along the communication task dimension, the risk is that miscommunication between producers and consumers will prevent transactions from occurring, effectively imposing transport costs on the export of communication-intensive goods and services. Each z will be completed with no communication problems with a probability of $e^{-\delta_{zi}}$, where

$$\delta_{zi} = \delta_z + \delta_i + (\delta_z * \delta_i) \quad (3)$$

δ_z captures the task-requirements of industry z , such as importance of communication with consumers, δ_i captures country-specific characteristics such as the language spoken in the country, and $(\delta_z * \delta_i)$ interacts country and task characteristics (e.g. the language spoken in a country should matter differently for tasks associated with answering customer service telephone calls than for tasks associated with assembling automobiles). Because the probability of communication failure is different for exporting than for FDI, let δ_{zi}^x denote the risk parameter for exporting and let δ_{zi}^I denote the risk parameter for FDI. In addition to the costs of potential contract failure or miscommunication, a standard iceberg-style trade cost, τ_{zi} , is applied to US exports of z to country i . $e^{-\tau_{zi}}$ represents the share of the good or service that survives transport. Each firm will choose trade or investment for each destination market based on whether expected profits, as a function of country and industry characteristics, are larger for exporting or for FDI.

1.3.2 Basic Environment

Consumers have CES preferences with elasticity of substitution $\sigma_z > 1$. A firm's profits from exporting can be written as

$$\pi_x = [e^{-(\tau_{zi} + \delta_{zi}^x + \theta_{zi}^x)} w_{us} a_{us}(z)]^{1-\sigma_z} B_i - f_x \quad (4)$$

Additional profits from locating production abroad for foreign consumption (FDI) are given by:

$$\pi_I = [e^{-(\delta_{zi}^I + \theta_{zi}^I)} w_i a_i(z)]^{1-\sigma_z} B_i - f_I \quad (5)$$

where a_{us} is the labor required to produce one unit of z in the US, a_i is the labor required to produce one unit of z in country i , w_i and w_{us} are the wages in each country, $B_i = (1 - \gamma)A^i/\gamma^{1-\sigma}$ is income share spent on z , f_x is the fixed cost of exporting, f_I is the fixed cost of FDI and $f_X < f_I$. a is drawn randomly by each firm from a pareto distribution, $G(z)$ and thus firms can be ordered from least productive to most productive. Each firm observes its productivity draw, and then decides whether or not to serve foreign markets and, if so, whether to use exporting or FDI sales. Relative profits of each production location depend on trade costs, relative productivity, a_i , wages, fixed costs, and risks associated with communication and contracting. These profit equations are very similar to those of Helpman, Melitz and Yeaple (2004) but incorporate the task-based trade costs.

From these profit equations, the cutoff for exporting can be written as:

$$[e^{-(\tau_{zi} + \delta_{zi}^x + \theta_{zi}^x)} w_{us} a_{us}(z)]^{1-\sigma_z} B_i = f_{xi} \quad (6)$$

and the cutoff for FDI can be written as:

$$[(w_i e^{-(\delta_{zi}^I + \theta_{zi}^I)})^{1-\sigma_z} - (w_{us} e^{-(\tau_{zi} + \delta_{zi}^x + \theta_{zi}^x)})^{1-\sigma_z}] (a_i(z))^{1-\sigma_z} B_i = (f_{Ii} - f_{xi}) \quad (7)$$

The firm will choose to export if $\pi_{xz} - \pi_{Iz} > 0$ and produce the task abroad through FDI if $\pi_{xz} - \pi_{Iz} < 0$. Thus the ratio of exports, X_{zi} , to FDI, I_{zi} is

$$\frac{X_{zi}}{I_{zi}} = \left(\frac{w_{us} e^{-(\tau_{zi} + \delta_{zi}^x + \theta_{zi}^x)}}{w_i e^{-(\delta_{zi}^I + \theta_{zi}^I)}} \right)^{1-\sigma_z} \left[\frac{V_s(a_{us}(z))}{V_s(a_i(z))} - 1 \right] \quad (8)$$

where $V(a) = \int_0^a y^{1-\sigma} dG(y)$ is the distribution of productivity. V is pareto with shape parameter $k - (\sigma - 1)$. This distribution implies that $V(a_{us})/V(a_i) = (a_{us}/a_i)^{k-(\sigma-1)}$. Plugging in using the cutoff values for FDI and exporting to get a_{us} and a_i , this condition becomes

$$\begin{aligned} \frac{X_{zi}}{I_{zi}} = & \left(\frac{w_{us} e^{-(\tau_{zi} + \delta_{zi}^x + \theta_{zi}^x)}}{w_i e^{-(\delta_{zi}^I + \theta_{zi}^I)}} \right)^{1-\sigma_z} \\ & * \left[\frac{f_I - f_x}{f_x} \frac{1}{(w_{us} e^{-(\tau_{zi} + \delta_{zi} + \theta_{zi})})^{\sigma_z - 1} (w_i e^{-(\delta_{zi} + \theta_{zi})})^{1-\sigma_z} - 1} \right]^{\frac{k-(\sigma_z-1)}{\sigma_z-1}} \end{aligned} \quad (9)$$

Linearizing this equation produces the primary regression specification:

$$\ln \frac{X_{zi}}{I_{zi}} = \beta_1 \ln \frac{w_i}{w_{us}} + \beta_2 \delta_{zi} + \beta_3 \theta_{zi} + \beta_4 \tau_{zi} + \beta_5 f_x + \beta_6 f_I + \beta_7 k \quad (10)$$

Where δ_{zi} denotes the net difference between δ_{zi}^x and δ_{zi}^I and θ_{zi} denotes the net difference between θ_{zi}^x and θ_{zi}^I .

I estimate a reduced form version of equation (11), where δ_{zi} and θ_{zi} are stacked in one vector, along with other country and industry characteristics, denoted by δ_{zi} , and replaced by Equation (3):

$$\ln \frac{X_{zi}}{I_{zi}} = \beta_1 \ln \frac{w_i}{w_{us}} + \beta_2 \tau_{zi} + \beta_3 k + \beta_4 \delta_z + \beta_5 \delta_i + \beta_6 (\delta_z * \delta_i) + \varepsilon_{zi} \quad (11)$$

This specification is similar to Brainard (1997) and Helpman, Melitz and Yeaple (2004). But in addition to the proximity-concentration trade off, communication risk and contract risk must also be balanced to make exporting more profitable than incurring the cost of opening a new plant in the final consumption market. We should see more

exports relative to FDI for countries with weak institutions and those that are linguistically distant. More nonroutine tasks are more vulnerable to contract risk and are thus more likely to be exported, especially when the destination country has weak contract-enforcing institutions. Communication-intensive tasks are associated with greater risk at the time and location of delivery to consumers and thus are more likely to be sold through FDI. So while the analytical result is similar to previous models of the trade versus investment decision for goods, the empirical implications are different.

1.4 Construction of Task Intensities

Autor, Levy and Murnane (2003) divide the set of all possible job tasks that workers perform into two basic categories: routine and nonroutine. Routine tasks are those that can be accomplished by following a set of specific, well-defined rules. Nonroutine tasks require more complicated activities like creative problem solving and decision making. These tasks are sufficiently complex that they can not be completely specified in computer code and executed by machines as emphasized by Autor, Levy and Murnane, nor can they be fully described in a written contract. I use this routine-nonroutine dichotomy and add another dimension, communication, which captures tasks that require interaction with customers. This activity has the largest average difference in importance between manufacturing and service industries. It also offers a meaningful measure of a characteristic that has often been cited as a intuitive explanation for why some activities are more offshorable than others, namely the extent to which producers and consumers must be in the same location at the time of delivery (Blinder 2007).

The Department of Labor’s Occupational Information Network (O*NET) includes data on the importance of these and other tasks in about 800 occupations. To match the relevant task measures to the industry-level trade and investment data, I aggregate the the raw O*NET scores up to the industry level, weight them by share in total task composition of each industry and merge them with trade data to get an index of the intensity of each task in each industry. Industries can then be defined by a vector of tasks, each weighted by its importance in that industry. O*NET lists 277 dif-

ferent skills, abilities, work activities, etc. Blinder (2007) and Jensen and Kletzer (2007) use this data to construct indices of the offshorability of service occupations. Bacolod, Blum, and Strange (2007) use O*NET’s predecessor, the Dictionary of Occupational Titles (DOT), to estimate the impact of agglomeration on the hedonic prices of worker skills. Autor, Levy and Murnane (2003) use the DOT to classify the extent to which industries and occupations are comprised of routine versus nonroutine tasks.

I combine data on the task requirements of occupations from O*NET with data on services and manufactures trade from the BEA to create an index of task intensity in each industry which will serve as a measure of trade costs in the export versus FDI framework described above. The importance score of each task, s in each industry, z is

$$M_{sz} = \sum_c \alpha_{zc} \ell_{sc} \quad (12)$$

where s indexes tasks, c indexes occupations, and z indexes industries. Thus α_{zc} is the share of occupation c used in the production of industry z , and ℓ_{sc} is an index of the importance of task s for occupation c .³ Summing over occupations in a given industry results in an index of the un-scaled importance score for each task in that industry. Each raw score is then divided by the sum of scores for each task in each industry, resulting in an input intensity measure for each task, s , in each industry, z :

$$I_{sz} = \frac{M_{sz}}{\sum_s M_{sz}} \quad (13)$$

Occupations are matched to industries using the Bureau of Labor Statistics Occupational Employment Statistics. These intensities are then matched to the BEA data on multinational firms. BEA collects data at the level of the firm and then reports

³ ℓ_{sc} corresponds to the 0-100 score O*NET reports to measure the importance of each task in each occupation. These scores are constructed from surveys of individuals in those occupations and are normalized to a 0-100 scale by analysts at the Department of Labor. Due to the subjective nature of the surveys, one unit of importance for given task can not be directly compared to one unit of another task. This is a limitation of the data and motivates the use of relative intensity scores rather than the raw scores reported by O*NET.

the primary industry classification of each firm. Thus (13) can be used as a component of the industry characteristics vector δ_z in regression equation (11).

I took two different approaches to distilling the O*NET data into a simple measure of each task characteristic. The first approach is similar to Autor, Levy and Murnane (2003) and consists of identifying an individual task measure that most closely proxies each desired characteristic. Under this approach, I use the O*NET measure “working with the public” as a proxy for the importance of communicating with consumers. To capture the level of task complexity (which corresponds to Autor, Levy and Murnane’s “non-routine cognitive” category), I use the O*NET measure of “creative thinking” As a robustness check, I replicate the regressions using “making decisions and solving problems” and “communicating inside the organization” as alternate measures of non-routine task intensity. I use the O*NET measures “handling objects” “operating machines (other than vehicles)” and “general physical activities” to proxy routine manual activities.

The second approach uses principal components analysis to distill a large number of tasks down to their core elements. I create one measure of non-routine intensity using the primary component among creativity, problem solving, giving consultation or advice, developing objectives, communicating internally, and working with computers. The routine manual component is drawn from the tasks handling objects, operating machines and general physical activities. No principal components were constructed for communication because working directly with the public is the single O*NET task that corresponds directly to that concept. All empirical results are robust to the use of individual task proxies or principal component measures.

1.5 Data

1.5.1 FDI Data

The Bureau of Economic Analysis collects firm-level data on U.S. multinational company operations in both goods-producing and service-producing industries in its benchmark surveys of U.S. direct investment abroad. I use data on local sales by foreign affiliates from these surveys as a measure of sales through FDI. The information on manufacturing firms contained in this dataset has been used in previous studies (see for example Hanson, Mataloni, and Slaughter 2005 or Desai, Foley and Hines 2001), however the data on service trade and investment are not frequently exploited. I restrict my sample to the years in which the Benchmark surveys were conducted. These include 1982, 1989, 1994, 1999, and 2004. The BEA surveys cover 54 manufacturing industries and 33 service industries, classified according to BEA versions of 3-digit SIC codes. For this paper, I aggregated the affiliate firm level data up to the industry level, defined by the primary industry of the affiliate, to be matched with industry level export data.

1.5.2 Export Data

Data on exports of manufactures are taken from the dataset compiled by Feenstra and available at the NBER website. These data were converted from 4-digit SIC codes to 3-digit BEA SIC-based codes using concordance tables provided by Raymond Mataloni. Data on exports of services were taken from BEA's survey of selected services transactions with unaffiliated foreign persons. This survey provides information on both the general product categories that are being traded and on the primary industry of the exporting firm, as reported by the firm itself. These classifications are highly correlated (e.g. we observe firms in the legal industry exporting legal services and firms in the advertising industry exporting advertising services). I use the industry of the exporting firm, rather than the product category, to classify service exports, as these codes are also used in the FDI data. Data from this survey are available annually beginning in 1992,

resulting in a final dataset containing three years (1994, 1999, and 2004), 54 manufacturing industries, 32 service industries, and 88 countries. Table 4 lists service industries in descending order of their export to FDI ratios.

There are a few key differences between the public versions of the BEA services trade data and the confidential BEA survey data I use for this paper. Based on BEA definitions, service exports reported in the public data occur when “the residents of one country sell services to the residents of another country.” (Nephew et al. 2005). This could occur in the US (e.g. a foreign resident travels to the US to purchase services) or abroad (a company located in the US provides services to an individual or company located in another country). These exports can be within firm or unaffiliated. Table 3 gives the values of these exports by major category in 2004. They include services that are classified by BEA as “other private services” These do not include travel, transportation, retail, or wholesale services. The largest categories are financial and business services, the latter of which includes information, management, telecommunications, legal, accounting, engineering, advertising, and other similar services. For this paper, I use firm-level data from BEA’s survey of selected services transactions with unaffiliated foreign persons, which is one component of the aggregate public data (compiled by BEA from several different sources). This survey covers a subset of other private service and only includes exports by U.S. companies to unaffiliated persons abroad. Therefore my analysis is not complicated either by intrafirm trade or by service exports sold to foreign citizens traveling to the U.S.

1.5.3 Institutional Quality Data

I use an index of regulation and enforcement from the World Bank’s Doing Business Database to proxy for the level of institutional quality. This index is based on surveys of local experts, including lawyers, business consultants, accountants, freight forwarders, government officials and other professionals routinely administering or advising on legal and regulatory requirements. The index includes an overall measure of

business institutions, as well as separate measures for ten specific areas: starting a business, protecting investors, dealing with construction permits, paying taxes, employing workers, trading across borders, registering property, getting credit, closing a business, and enforcing contracts. Countries are ranked based on their strength on each of these dimensions. Each country’s score for each dimension is its rank from 1 to 181. The overall score for a country is the simple average of that country’s scores on each of the ten dimensions. I normalize these rankings to fall between 0 and 100, with 100 representing the highest level of institutional quality. For the baseline specification, I use the difference between the contracting institutions score and the overall score to isolate the specific role of contract enforcement apart from the overall business environment. As a robustness check, I also use the overall measure of institutional quality for each country.

1.5.4 Other Data

The great circle distance between capital cities proxies for transport costs. GDP is used to capture market size. Data on firm-level sales by industry from Compustat are used to construct a measure of productivity dispersion for each industry in the sample. Relative wages in manufacturing and services are constructed using data from Freeman and Oostendorp (2000). As a robustness check, I also use a ratio of high to low skill wages from Grogger and Hanson (2008), which defines low-skill wages as the income level at the 20th percentile and high-skill wages as the income level at the 80th percentile. Data on corporate tax rates are from the University of Michigan World Tax Database. I use data on the educational level of industries from the Department of Labor’s O*NET database. O*NET assigns each occupation a score of 1 to 5 to indicate the level of education and training required for that occupation. I aggregate those occupational level scores up to the industry level using the same occupation shares for each industry described by equation (12) in Section 4. The linguistic distance between countries based on language trees from Fearon (2003) is used to capture the effect of language. The more nodes on these trees that two languages have in common, the more

likely they are to trace their roots to a recent common ancestor language. In this sense, the number of common nodes (out of a possible total of 15) that two languages share can be used to measure their linguistic similarity. Fearon (2003) also provides information on the linguistic composition of countries. Combining the information on language trees with the linguistic composition of countries results in a linguistic distance measure for each country, which is bounded by 0 and 1 and increasing in linguistic distance. For correlations between these and other variables, see Table 4.

1.6 Empirical Specification

1.6.1 Two-Stage Estimator

Helpman, Melitz, and Rubinstein (2008) demonstrate that standard gravity models suffer from bias because they do not account for the empirical fact that not all countries trade all goods with all other countries. Ignoring these zero-valued observations results in selection bias, as trade volumes are only observed for those countries that choose to trade with each other.

Figure 2 shows the share of country-industry pairs for which the US has zero exports, zero FDI sales, or an undefined or zero-valued export to FDI ratio in the manufacturing and service sectors. These patterns suggest that zero-valued observations are an even greater concern for the study of services than manufacturing. Correcting for selection into service exports or FDI is especially important if the biases are more systematic than in manufacturing, which could be the case if the task characteristics of certain service industries make them nontradable or if individual countries have restrictions barring service-sector FDI or trade.

I correct for selection into exporting and FDI sales using the non-parametric two-stage estimator proposed by Helpman, Melitz, and Rubinstein (2008). This estimator has the advantage of controlling both for the endogenous number of firms engaged in export and FDI and for bias due to correlation between the error term and the independent variables, which is generated by the selection of country-industry pairs into

non-zero exports and FDI (e.g. a Heckman (1979) selection correction), but without the normality assumptions required by a similar parametric estimator. A disadvantage of the non-parametric functional form is that it does not allow for decomposition of the two types of bias. However, because the goal of this paper is to get unbiased estimates of the determinants of the export-FDI ratio, rather than to decompose the potential sources of bias, I am less concerned with this limitation. I also follow Helpman, Melitz and Rubinstein in using an index of common religion as the necessary exclusion restriction. They show that this measure only impacts the probability of trade, not the volume and I confirm that it holds for the probability of existence (but not volume) of the export-FDI ratio.

The log of the export to FDI ratio could be undefined either because exports equal zero, FDI sales equal zero, or both. However, positive selection into the sample of export-FDI observations occurs only if both exports and FDI sales are strictly positive. Therefore, I do not distinguish between the source of an undefined log export-FDI ratio and estimate the likelihood that both exports and FDI sales exist based on observables in the first stage, and then control for this selection in the second stage. Define indicator variable T_{zi} to equal 1 if the log of the export to FDI ratio exists, that is, if US has both non-zero exports and non-zero FDI sales to country i in industry z . Thus the two stage estimator is:

Stage 1:

$$\rho_{zi} = Pr(T_{ij} = 1 | \text{observed variables}) = \Phi(\gamma_0 + \gamma_1) \quad (14)$$

Stage 2:

$$\ln \frac{X_{zi}}{I_{zi}} = \beta_1 \ln \frac{w_i}{w_{us}} + \beta_2 \tau_{zi} + \beta_3 k_z + \beta_4 \delta_z + \beta_5 \delta_i + \beta_6 (\delta_z * \delta_i) + \beta_7 \hat{\rho}_{zi} + e_{zi} \quad (15)$$

Where γ_1 is the vector of independent variables and $\hat{\rho}_{zi}$ is the predicted value from stage 1.

I estimate equation (15) several times: using the specification listed above, including separate controls for zero-valued exports and zero-valued FDI sales, and without any corrections for selection bias. The coefficients and significance on each of the task measures are not changed much with inclusion of bias controls.

1.7 Results

1.7.1 Testing the Proximity-Concentration Story

Table 6 gives the results of a proximity-concentration model of the export versus FDI decision run on separate samples of manufacturing and service industries. The results for manufacturing industries are consistent with previous papers on the export-FDI trade off. Consistent with a proximity explanation, the coefficient on physical distance is negative and significant for manufactures. The coefficient on GDP, which can be interpreted as a measure of market size, is also negative for the sample of manufactures. Taken together, these results suggest that firms are more likely to serve foreign markets through FDI sales when those markets are far away (making transport of exports more costly) and when those markets are large (making it easier to recover the fixed costs of setting up a local affiliate branch). Table 6 also shows that these results do not hold for service industries, suggesting that a distance-market size tradeoff is not driving the decision of service firms to serve foreign markets through FDI or export.

The variable *dispersion* is the standard deviation of sales by firms in each industry. It was constructed using total sales information on US firms from the Compustat database. This variable captures the degree of firm level heterogeneity within an industry that was emphasized by Helpman, Melitz, and Yeaple (2004). Consistent with their results, I find that greater firm-level heterogeneity significantly increases FDI relative to

exports in an industry. This result holds for both manufacturing and service industries.

Another possible explanation for production location decisions is that firms prefer to locate production in countries with lower relative labor costs. This is generally thought of as a motive for vertical FDI, but may be relevant here to the extent that firms engage in both vertical and horizontal FDI (see for example Yeaple 2003 and Carr, Markusen and Maskus 2001). I measure the relative wage in a number of different ways. The results presented in Table 6 show the average wage in service industries relative to the average wage in manufacturing industries for country i . The results in Table 6 suggest the wage ratio is not driving the export to FDI ratio in service or manufacturing industries. In other specifications not reported here, I also use the measure of high to low skilled wages proposed by Grogger and Hanson (2008) and either the destination country manufacturing wage relative to the US manufacturing wage and the destination country service wage relative to the US service wage. None of these relative wage measures are significant predictors of the export versus investment decision for either manufacturing or service industries.

Differences in corporate tax rates between the US and the destination country are not significantly associated with the export to FDI ratio. I define this variable as the US top marginal corporate tax rate minus the top marginal corporate tax rate in the destination country. Previous literature has found that tax rates matter for the location of affiliates of US multinationals (Grubert and Mutti 1991, Desai, Foley and Hines 2002). However, these studies do not look at sales to the local market by affiliates of US multinationals. Instead, their results suggest that those tax-driven locations are generally used for production for further export. It is therefore not inconsistent to observe that local sales by affiliates relative to exports from the US are not determined by differences in corporate tax rates.

1.7.2 The Role of Communication Tasks

Table 7 shows the results of the task-based model using communication and nonroutine tasks separately. Table 8 shows the results including communication and nonroutine tasks in the same regression. The negative coefficient on *communication* in tables 7 and 8 suggests that industries that require a higher degree of interaction with the public are more likely to be sold through FDI than through exports. Because services use communication tasks much more intensively than manufactures, this relationship is important for explaining why service firms use FDI rather than exports to a greater extent than do manufacturing firms. This result is not surprising, as FDI brings production closer to the final consumers. However, the simple and intuitive relationship between the need to communicate with customers and the propensity to use FDI rather than exporting is new to the literature.

I also interact the communication measure with contracting institutions and linguistic distance. Neither of these interactions has a significant coefficient for the sample of manufacturing industries. For services, the interaction of communication with institutional quality is positive and significant in Table 7. So while the need to communicate with customers generally leads to greater relative FDI sales, if the destination country has strong contracting institutions then communication-intensive services are more likely to be exported. This suggests that the way service firms communicate with customers differs from that of manufacturing firms, and that this difference is related to the need for strong contracting institutions.

1.7.3 The Role of Nonroutine Tasks

The importance of nonroutine tasks in an industry is positively correlated with the educational level of workers in that industry (see Table 5). Therefore I control for the average educational level of workers in each industry using the O*NET education measure described in Section 5. Industries requiring higher educational levels are more

likely to produce in the US for export rather than offshore production through FDI. However, nonroutine task intensity is significant even when education is controlled for. In the sample of service industries, the educational level of the industry is not significant when included in the same regression as the task measures, suggesting that nonroutine tasks play a role in the production location decision that is distinct from their educational content.

The importance of nonroutine tasks in an industry significantly increases relative exports. This result is consistent with the contracting model proposed in Section 3. Because nonroutine tasks can not be fully specified in contracts, they are subject to greater risk when their production is contracted out to affiliates in the destination market. Given that services are more nonroutine task intensive than manufactures, this relationship works in the opposite direction of communication intensity in that it increases the relative exports (rather than FDI) of service firms compared to manufacturing firms, offsetting some of the effect of the need to communicate with consumers.

The coefficient on contract enforcement is negative, implying that FDI relative to exports is higher for countries with stronger contract-enforcing institutions. This result is consistent with the contracting model proposed in Section 3. The coefficient on institutions interacted with nonroutine task intensity is also negative. In other words, an increase in the quality of contracting institutions increases relative FDI sales for nonroutine industries to a greater extent than for routine industries. This result also supports the contracting model in which institutions matter more for activities that are more difficult to fully specify in a complete contract.

Taken on its own, the positive relationship between nonroutine tasks and exporting could potentially be explained by a US endowment-based comparative advantage in non-routine cognitive tasks. However, interactions of routinization with both contract enforcing institutions and linguistic distance are significant. To the extent that a country's institutions and language are not associated with a relative abundance of the factors used intensively in the production of nonroutine tasks, then the significance of these in-

teractions can be taken as evidence for a contracting model over a comparative advantage model. To further identify the role of tasks separately from a comparative advantage story, I include controls for traditional endowment-based comparative advantage. These controls are interactions between the non-routine task intensity of each industry with the skill abundance of each country (see Table 9). Following Romalis (2004), this comparative advantage story can be tested by interacting each country’s relative endowment of a given factor with the relative intensity with which this factor is used in each industry. Because I do not have data on endowments of tasks by country, I use the skill level of the workforce from Hall and Jones (1999) to proxy for endowment of factors used in the production of nonroutine task-intensive goods and services. Nonroutine tasks are associated with higher skilled labor. If the location of these tasks was determined by traditional sources of comparative advantage, we would expect them to be produced in more skill-abundant countries. However, Table 9 shows that the skill interactions are not significant and the coefficients on nonroutine task intensity, both alone and interacted with institutions or linguistic distance, are still significant even when skill interactions are controlled for. To the extent that institutions can be considered an input into the production of more nonroutine goods and services, the institution-nonroutine interactions may still be interpreted as evidence of comparative advantage. However, this is more likely to be the case for overall institutional quality rather than contract enforcement. The definition of contracting institutions as the strength of contract enforcement relative to the overall business environment isolates this channel and provides support for the contracting model, which is still significant even traditional comparative advantage controls are included.

Table 10 shows the results of a similar exercise using a different definition of comparative advantage controls. Rather than interacting task intensity with relative skill endowment, this exercise uses standard interactions of relative skill endowment with relative skill intensity and relative capital endowment with relative capital intensity following Romalis (2004). The data on industry level intensities come from the NBER Manufac-

turing Database and are not available for service industries. However, Table 10 shows that these comparative advantage measures are not significant when the nonroutine task interactions are also included for the sample of manufacturing industries. It may seem surprising that the intensity-endowment interactions are not significant. However, we would expect the results to be weaker than in Romalis, given that this exercise only uses one exporter (the US) and compares the relative importance of the ways in which the US serves each market, not the standard exercise of looking at who specializes in what given a large set of potential producing countries and industries. The key result is still that for the export to FDI decision of US firms already serving foreign markets in a given industry, task intensities are more significant than measures of comparative advantage.

To ensure that the results are not being driven by the specific measure of nonroutine tasks used in this specification, I reran the regressions using the principal component measure of nonroutine task intensity. Table 11 shows that similar results are obtained when principal components are used in place of individual task measures.

1.7.4 The Role of Language

The coefficient on linguistic distance is positive and significant, suggesting that linguistic distance imposes a cost on FDI that is greater than the cost it imposes on exports. The coefficient on the interaction between the non-routine tasks and linguistic distance is negative. So firms are more likely to sell nonroutine task intensive goods through a local affiliate rather than exporting when the destination market is linguistically distant, a result that is consistent with the theoretical model. More complex tasks are generally more amenable to exporting than to FDI, however, the increased complexity leads to a greater translation cost (more is “lost in translation”) of exports when countries are linguistically distant, above and beyond exports of more routine industries to linguistically distant countries or exports of nonroutine goods to linguistically similar countries. A plot of the linguistic distance to export ratio by industry shows that this result is driven by highly interactive services such as advertising in countries that are

linguistically distant from the US. However, the result still holds even when advertising is excluded from the sample.

1.7.5 Country and Industry Fixed Effects

The above regressions do not include country or industry fixed effects in order to examine variation in the industry-specific task measures and the country-specific language and institutions measures. Table 9 shows the results of a series of regressions which include both country and industry fixed effects and examine variation in the interactions between linguistic distance and the task measures. Again, the general results from Tables 7 and 8 still hold. More nonroutine task intensive industries are more likely to be sold through FDI in countries with stronger contract enforcing institutions. The role of delivery intensity is independent of contracting institutions and linguistic distance.

1.7.6 Explaining Differences in Trade and Investment Patterns between Manufacturing and Service Industries

These results support the model in which differences in trade and investment patterns between goods and services can be explained at least in part by their differential task compositions. In this section, I use a Oaxaca-Blinder decomposition to quantify how much of the difference can be explained the different task intensities across sectors. This method, developed by Blinder (1973) and Oaxaca (1973) separates the difference in predicted values for two groups in to the shares that are attributable to the difference in the levels of each variable (endowments) across groups, the difference in the coefficients across groups, and the difference in interactions between endowments and coefficients.

Table 13 decomposes the baseline specification. The differences in the endowments between manufacturing and service industries account for 40 percent of the total difference in the export to FDI ratios across these two sectors. Of this 40 percent, nearly all of it can be explained by differences in the task intensity measures. Differences in

education levels between manufacturing and services only explain 1 percent of the difference in the export to FDI ratio. Of the remaining 60 percent of the total difference, 55 percent is explained by differences in coefficients across the two sectors and 5 percent is explained by the interaction between endowments and coefficients.

To quantify the level of these differences, recall that the task intensities represent the importance score of a given task re-scaled to reflect the share of that task in the sum of total importance scores across all work activities. So the coefficients on task intensities give the percentage change in the export to FDI ratio for a one point increase in the task intensity of an industry. To isolate the average effects of communication and nonroutine intensity, I use coefficients from the specification without interaction terms presented in Table 12. The coefficient on communication task-intensity implies that a 1 point increase in the communication intensity score of an industry will lead to a 69 percent decrease in the share of exports relative to FDI sales in that industry. On average, services have a communication intensity that is 1.22 points higher than the delivery intensity of manufactures. Holding all else constant, we would expect the export share in services to be 85 percent lower than in manufactures. The coefficient on nonroutine task-intensity from Table 12 implies that a 1 point increase in nonroutine intensity leads to an 89 percent increase in the share of exports relative to FDI. On average, the non-routine task intensity of services is 0.44 points higher than that of manufactures. Holding all else constant, this corresponds to an export-FDI ratio that is 39 percent higher for services than for manufacturing. Together, these two task measures would predict that the export FDI share for service industries is about 46 percent less than for manufactures. In 2004, the export to FDI ratio in manufacturing industries was 1.04 and the export FDI ratio for services was 0.40, or 62 percent lower than for manufactures. In 1999, the export to FDI ratio was 72 percent lower for services than for manufactures. So these two task variables alone explain about 64 to 74 percent of the difference between the ratio of exports to FDI in services versus manufactures. A portion of the remaining difference can be explained by the role of distance, which significantly decreases the export share

for manufactures but not services.

1.8 Robustness Checks

I also ran the specifications described above on several subsets of the service industries to investigate whether or not a few highly traded services were driving the results. For this exercise, I defined highly tradable services in five different ways: first as those industries in which at least 20 percent of foreign sales occur through exports rather than FDI, second as those industries in which at least 10 percent of foreign sales occur through exports rather than FDI, third as the top five industries ranked by level of exports, fourth as the top ten industries ranked by level of exports, and fifth as the as the top fifteen industries ranked by level of exports. No consistent patterns emerge among more and less traded service industries, suggesting that the results are not being driven by a subset of highly tradable services.

One drawback of using the export to FDI ratio is that it masks the underlying volumes of trade and investment such that an country-industry observation with \$2 million in exports and \$1 million in FDI sales would be indistinguishable from a country-industry observation with \$20 billion in exports and \$10 billion in FDI sales. To ensure that the results were not biased by this weighting effect, I re-ran the model using only the smallest third, middle third, and largest third of industry-country observations, defined by total foreign sales. The results for all three of these subsets were consistent with those using the full sample.

1.9 Conclusion

Manufacturing and service producing firms use exports and FDI in different proportions. In this paper, I demonstrate that market size and distance are significant predictors of the export to FDI ratio for manufactures but not for services. To explain the difference across sectors, I focus on two new sources of the relative costs of FDI and

exports. The first of these is the need to communicate with consumers. I provide rigorous empirical support to the intuitive idea that industries requiring greater interaction with consumers are more likely to locate production near those consumers through the use of FDI. Because communicating with consumers is about twice as important for services as for manufactures, this variable can explain why service firms use FDI relative to exports at a much higher rate than manufacturing firms.

The second new variable captures a hidden cost of FDI: the difficulty of contracting nonroutine activities to foreign affiliates. Industries that are more intensive in their use of nonroutine tasks are more likely to produce at home for export rather than offshoring to foreign affiliates. Because services are more nonroutine task intensive than manufactures, this relationship partially offsets the propensity towards FDI in services implied by the role of communicating with consumers. Differences in these two task measures between manufacturing and services can explain 40 percent of the difference in export to FDI ratios across the sectors.

1.10 References

- Acemoglu, Daron, Paul Antras, and Elhanan Helpman, 2007, Contracts and Technology Adoption. *The American Economic Review*, 97(3), pp. 916-943.
- Amiti, Mary and Shang Jin Wei, 2004, Fear of Service Outsourcing: Is it Justified? *Economic Policy*, 20(42), pp. 308-347.
- Anderson, James and Douglas Marcouiller, 2002, Insecurity and the pattern of Trade. *Review of Economics and Statistics*, 84(2), pp. 342-352.
- Autor, David, Frank Levy, and Richard Murnane, 2003, The Skill Content of Recent Technological Change: an Empirical Exploration. *Quarterly Journal of Economics* 118(4), pp.1279-1333.
- Bacolod, Marigee, Bernardo Blum, and William Strange, 2007, Skills in the City. Working Paper.
- Blinder, Alan, 2007, How Many U.S. Jobs Might be Offshorable? CEPS Working Paper No. 142
- Blinder, Alan, 1973, Wage Discrimination: Reduced Form and Structural Estimates. *The Journal of Human Resources*, 8, pp. 436-455.

- Brainard, Lael, 1997, An Empirical Assessment of the Proximity-Concentration Trade-off between Multinational Sales and Trade. *American Economic Review*, 87, pp. 520-544.
- Brainard, Lael, 1993, A Simple Theory of Multinational Corporations an Trade with a Trade-off between Proximity and Concentration. National Bureau of Economic Research Working Paper No. 4269.
- Carr, David, James Markussen, and Keith Maskus, 2001, Estimating the Knowledge-Capital Model of the Multinational Enterprise, *American Economic Review*, 91, pp. 691-708.
- Costinot, Arnaud, 2008, On the Origins of Comparative Advantage. Working Paper.
- Desai, Mihir, Fritz Foley, and James Hines Jr., 2002, Chains of Ownership, Regional Tax Competition, and Foreign Direct Investment. NBER Working Paper No. W9224.
- Desai, Mihir, Fritz Foley and James Hines Jr., 2001, Repatriation Taxes and Dividend Distortions, *National Tax Journal*, 54, pp. 829-851.
- Fearon, James, 2003, Ethnic and Cultural Diversity by Country. *Journal Journal of Economic Growth*, 8(2), pp. 195-222
- Feenstra, Robert, John Romalis and Peter Schott, 2002, U.S. Imports, Exports, and Tariff Data, 1989-2001. NBER Working Paper 9387.
- Freeman, Richard B. and Remco Oostendorp, 2000, Wages Around the World: Pay Across Occupations and Countries. NBER Working Paper No. W8058.
- Freund, Caroline, Weinhold Diana, 2002. The Internet and International Trade in Services. *AEA Papers and Proceedings* 92(2), 236-240.
- Grogger, Jeffrey and Gordon Hanson, 2008, Income Maximization and the Selection and Sorting of International Migrants. NBER Working Paper No. 13821.
- Grossman, Sanford and Oliver Hart, 1986, The costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration. *Journal of Political Economy*, 94(4), pp. 691-719.
- Grossman, Gene and Esteban Rossi-Hansberg, 2006, Trading Tasks: A Simple Theory of Offshoring. NBER Working Paper No. W12721.
- Grubert, Harry and John Mutti, 1991, Taxes, Tariffs and Transfer Pricing in Multinational Corporate Decision Making Harry Grubert and John Mutti. *The Review of Economics and Statistics*, 73(2), pp. 285-293
- Hall, Robert E and Charles I. Jones, 1999, Why Do Some Countries Produce So Much More Output Per Worker Than Others? *Quarterly Journal of Economics*, 114(1), pp. 83-116.

- Hanson, Gordon, Raymond Mataloni, Jr. and Matthew Slaughter, 2005, Vertical Production Networks in Multinational Firms. *Review of Economics and Statistics*, 87(4), pp.664-678.
- Hanson, Gordon and Chong Xiang, 2008, International Trade in Motion Picture Services. working paper.
- Heckman, James, 1979, Sample Selection Bias as a Specification Error. *Econometrica*, 47(1).
- Helpman, Elhanan, 1984, a simple theory of international trade with multinational corporations. *Journal of Political Economy*, 92(3), pp. 451-471.
- Helpman, Elhanan, Marc Melitz and Yona Rubinstein, 2008, Estimating Trade Flows: Trading Partners and Trading Volumes. *Quarterly Journal of Economics*, 123(2), pp. 441-487.
- Helpman, Elhanan, Marc Melitz and Stephen Yeaple, 2004, Export versus FDI with heterogeneous firms. *American Economic Review*, 94, pp. 300-16.
- Jensen, J. Bradford and Lori Kletzer, 2007, Measuring Tradable Services and the Task Content of Offshorable Services Jobs. In K. Abraham, M. Harper and J. Spletzer, eds., *Labor in the New Economy*, University of Chicago Press, forthcoming.
- Jensen, J. Bradford and Lori Kletzer, 2005, Tradable Services: Understanding the Scope and Impact of Services Outsourcing. Peterson Institute Working Paper Series WP05-9, Peterson Institute for International Economics.
- Kremer, Michael, 1993, The O-Ring Theory of Economic Development. *The Quarterly Journal of Economics*, 108(3), pp. 551-575.
- Krugman, Paul, 1983, The 'New Theories' of International Trade and the Multinational Enterprise. In D.B. Audretsch and Charles Kindleberger, eds, *The Multinational Corporation in the 1980s*. Cambridge, MA: MIT Press, 1983, pp. 57-73.
- Markusen, James, 1984, Multinationals, multi-plant economies, and the gains from trade. *Journal of International Economics*, 16(3), pp. 205-226.
- Markusen, James, 1997. "Trade versus Investment Liberalization," NBER Working Papers 6231, National Bureau of Economic Research, Inc.
- Markusen, James and Keith Maskus, 2002, Discriminating Among Alternative Theories of the Multinational Enterprise. *Review of International Economics* 10(4) , pp. 694-707.
- Nephew, Erin, Jennifer Koncz, Maria Borga, and Michael Mann, 2005, US International Services: Cross-Border Trade in 2004 and Sales Through Affiliates in 2003, *Survey of Current Business* 85 (October 2005), pp. 25-77.
- Oaxaca, Ronald, 1973, Male-Female Wage Differentials in Urban Labor Markets. *International Economic Review*, 14, pp. 693-709.

Romalis, John, 2004, Factor proportions and commodity trade. *American Economic Review*, 94(1), pp. 67-97.

Yeaple, Stephen, 2003, The complex integration strategies of multinationals and cross country dependencies in the structure of foreign direct investment. *Journal of International Economics*, 60, pp. 293-314.

2 Adaptation and the Boundary of Multinational Firms (coauthored with Arnaud Costinot and James Rauch)

2.1 Introduction

Many aspects of contractual incompleteness have been analyzed in the theoretical international trade literature as explanations for why multinationals should prefer internal versus external procurement,⁴ but just two strands of this literature have dominated empirical application. The older strand (e.g., Ethier 1986, Markusen 1995) emphasizes difficulty in enforcing intellectual property rights in the countries that host the multinational subsidiaries. Employing the “knowledge capital” model of multinational firms, these papers argue that when multinationals have important trade secrets to protect, this is done more easily if the manufacturing process is kept within the firm. The newer strand (e.g., Antras 2003, Antras and Helpman 2004, 2008) emphasizes the holdup problem that arises when the multinational headquarters and its supplier have to make noncontractible relationship-specific investments *ex ante*. Applying the insight of Grossman and Hart (1986), these papers argue that property rights in the output of the relationship should be held by the party whose incentive to invest is more important, hence supply should be kept within the multinational firm when its headquarters makes the larger contribution to the relationship.⁵

In this paper we emphasize a different source of contractual frictions that arises *ex post* due to the nonroutine quality of many activities a supplier must undertake for a multinational headquarters. The premise of our analysis is that some activities are more likely than others to give rise to problems the nature of which cannot be fully specified in a contract *ex ante*. When these unspecifiable situations arise the headquarters and its supplier must adapt, and this adaptation is more efficiently carried out within a firm

⁴See Helpman (2006) and Antras and Rossi-Hansberg (2008) for recent surveys of this literature.

⁵Recent empirical tests of the property rights model of the multinational include Feenstra and Hanson (2005), Yeaple (2006), Defever and Toubal (2007), Tomiura (2007), Bernard et al. (2008), Carluccio and Fally (2008) and Nunn and Trefler (2008). For empirical tests of the knowledge-capital model, see e.g. Carr et al. (2001) and Yeaple (2003).

because incentives for opportunistic behavior are lower, because ex post renegotiation is less costly or because of internal communications infrastructure. By emphasizing ex post adaptation in an uncertain environment, we build on fundamental contributions by Simon (1951) and Williamson (1975) and on the recent synthesizing work of Tadelis (2002) and Gibbons (2005).⁶ In section 2.2 below we describe in more detail the theoretical arguments for why nonroutine activities are more likely to be supplied internally, but we will not take a stand on which argument is the most important.

To investigate whether or not “routineness” is an important determinant of the boundary of multinational firms, we first need data on multinational activities. Following Antras (2003), Yeaple (2006), Nunn and Treffer (2007), and Bernard et al. (2008), we use sector level data on the intrafirm imports of U.S. multinationals. The United States is the world’s biggest foreign direct investor, with subsidiaries abroad worth \$2.9 trillion in 2006. The share of U.S. imports that is intrafirm is both remarkably high, 47% in 2006, and widely varying across industries, from 4% in footwear to 92% in motor vehicles. It is not surprising that these data have proven to be a rich source of insight into multinational behavior.

To give empirical content to the notion of “routineness” we build on the work of Autor, Levy, and Murnane (2003). They used the U.S. Department of Labor’s Dictionary of Occupational Titles (DOT) to classify occupations as routine or nonroutine. We use the Department of Labor’s successor to the DOT, the Occupational Information Network (O*NET), to order occupations from lowest to highest intensity in “problem solving.”⁷ To guide our empirical analysis, we relate these data to a simple trade model where occupations are interpreted as “tasks” that are embodied in imports by U.S. multinational firms, and intensity in “problem solving” is interpreted as a measure of the need for ex post adaptation by a headquarters and a supplier, to which we refer as “task routineness.” Within this environment, we say that a sector is less routine than

⁶For an application of the adaptation approach to vertical integration in the U.S. airline industry, see Forbes and Lederman (2008).

⁷O*NET has also been used by Blinder (2007) and Jensen and Kletzer (2007).

another if its distribution of employment over the ranked tasks is first-order stochastically dominant.⁸ The main prediction of our simple trade model is that if vertical integration increases productivity ex post, but reduces it ex ante, then less routine sectors should have a higher intrafirm share of import value.

Keeping as close to our theory as possible for our first empirical test, we consider sign tests for all pairs of sectors that can be ranked in terms of routineness. Sign tests offer mild, but encouraging support for our prediction: in 67% of all cases, the less routine sector has a higher intrafirm share of import value. This should not be too surprising since they do not control for any other determinant of the boundary of multinational firms.

In order to control for these other determinants, we then turn to cross-sector regressions with country fixed effects. Within chains of sectors that can be ranked in terms of routineness, we find that average task routineness is a strong predictor of the intrafirm share of imports. According to our most conservative estimate, a one standard deviation decrease in the average task routineness of a sector leads to a 0.26 standard deviation increase in the share of intrafirm imports, or an additional 7% of import value that is intrafirm. This result is robust to inclusion of the other variables shown by previous studies to influence the U.S. intrafirm import share.

As a robustness check, we also rerun these regressions using alternative samples of sectors, including the full sample of 4-digit NAICS industries, and an alternative sample of countries. In all cases, we obtain qualitatively similar results: less routine sectors have a higher share of intrafirm trade. Overall, we view these results as strongly supportive of the main hypothesis of our paper: adaptation is an important determinant of the boundary of multinational firms.

In the next section of this paper we develop a simple theoretical model of the determinants of industry variation in the intrafirm share of U.S. imports. Section 2.3 describes our data sources and provides some descriptive statistics. We present our

⁸We come back to the role of this definition, which is central to our empirical strategy, in Section 2.2.

empirical results in section 2.4 and robustness checks of these results in section 2.5. Our conclusions are in section 2.6.

2.2 Theoretical Framework

2.2.1 Basic environment

Consider a world economy with $c = 1, \dots, C$ countries; $s = 1, \dots, S$ goods or sectors; $t = 1, \dots, T$ tasks; and one factor of production, labor, immobile across countries. We denote by w_c the wage per efficiency unit in country c . There are two types of firms, intermediate suppliers and final good producers. Intermediate suppliers are present in all countries. They transform labor into tasks using a constant-returns-to-scale technology. The total output of task t in sector s and country c is given by

$$Y_c^s(t) = \frac{L_c^s(t)}{a_c(t, X)} \quad (16)$$

where $L_c^s(t) \geq 0$ is the amount of labor allocated to task t in sector s and country c ; and $a_c(t, X) > 0$ is the amount of labor necessary to perform task t once in country c . The role of X will be described in detail in a moment. Final good producers only are present in country 1, the United States. They transform tasks into goods using a Cobb-Douglas technology. The total amount of good s produced with tasks from country c is given by

$$Y_c^s = \prod_{t=1}^T [Y_c^s(t)]^{b^s(t)} \quad (17)$$

where $1 \geq b^s(t) \geq 0$ and $\sum_{t=1}^T b^s(t) = 1$. We refer to $b^s(t)$ as the intensity of task t in sector s . All markets are perfectly competitive. Final goods are freely traded, whereas tasks are nontraded. Under these assumptions, Y_c^s represents the quantity of U.S. imports from country $c \neq 1$ in sector s . In our model, tasks are “embodied” in imports, like factor services in traditional trade models.

2.2.2 Adaptation and the make-or-buy decision

For each task, there exist two states of the world, “routine” and “problematic”. Tasks only differ in their probabilities $\mu(t)$ of being in the routine state. $\mu(t) \geq 0$ is an exogenous characteristic of a task, to which we refer as its routineness. Without loss of generality, we index tasks such that higher tasks are less routine, $\mu'(t) < 0$.

For each task and each country, final good producers in the United States can choose between two organizations, $X \in \{O, I\}$. Under organization I (Integration), U.S. final good producers own their intermediate suppliers at home or abroad, whereas under organization O (Outsourcing), intermediate suppliers are independently owned. The premise of our analysis is that firms’ organizational choices affect productivity at the task level both ex ante and ex post. Let $a_c(t, X) > 0$ denote the amount of labor necessary to perform task t once in country c under organization X . We assume that $a_c(t, X)$ can be decomposed into

$$a_c(t, X) = \alpha_c(X) + [1 - \mu(t)] \beta_c(X) \quad (18)$$

where $\alpha_c(X) > 0$ is the ex ante unit labor requirement, and $\beta_c(X) > 0$ is an additional ex post unit labor requirement capturing the amount of labor necessary to deal with the problematic state.

The central hypothesis of our paper is that:

H₀. *In any country $c = 1, \dots, C$, integration lowers productivity ex ante, $\alpha_c(I) > \alpha_c(O)$, but increases productivity ex post, $\beta_c(I) < \beta_c(O)$.*

According to H_0 , the basic trade-off associated with the make-or-buy decision is that integrated parties are less productive ex ante, but more productive ex post. Though H_0 admittedly is reduced form, there are many theoretical reasons, as we briefly mention in the introduction, why it may hold in practice:

1. *Opportunism.* It is standard to claim that external suppliers have stronger incentives to exert effort than internal suppliers (e.g., Alchian and Demsetz 1972, Holmstrom 1982),

so that contracting out yields a cost advantage to headquarters ex ante. When problems require the parties to go beyond the contract ex post, however, opportunities for suppliers to “cut corners” may open up and their stronger incentives to reduce costs can backfire on headquarters (Tadelis 2002).⁹

2. *Renegotiation.* Although contracting out reduces cost ex ante, an arm’s length contract between headquarters and a supplier can lead to costly delays ex post when problems force renegotiation (Bajari and Tadelis 2001). Exercise of command and control within the firm avoids renegotiation costs.

3. *Communication.* Cremer, Garicano, and Prat (2007) argue that agents within the boundary of a firm develop a common “code” or “language” to facilitate communication.¹⁰ Building up this communications infrastructure is a superfluous expense when a standard contract can convey all necessary information to a supplier ex ante, but if problems arise ex post that a contract does not cover, a common language shared by the headquarters and the supplier will reduce the cost of the communication necessary to resolve them.

2.2.3 Testable implications

Let $X_c^*(t) \in \{O, I\}$ denote the organization chosen by final good producers (if any) purchasing task t from country c . Profit maximization requires

$$X_c^*(t) = \underset{X \in \{O, I\}}{\operatorname{argmin}} a_c(t, X) \quad (19)$$

The first implication of our theory can be stated as follows.

Lemma 1 *Suppose that H_0 holds. Then for any country $c = 1, \dots, C$, there exists $t_c^* \in \{0, \dots, N\}$ s.t. task t is outsourced if and only if $t \leq t_c^*$.*

⁹Tadelis in turn cites Williamson (1985, p. 140), who wrote that “low powered incentives have well known adaptability advantages.”

¹⁰Their model is based on the Arrow (1974) conception of the firm as a community specialized in the creation and transfer of knowledge. Azoulay (2004) finds that pharmaceutical firms assign “knowledge-intensive” projects to internal teams and outsource “data-intensive” projects.

Proof. Let $\Delta_c(t) \equiv a_c(t, O) - a_c(t, I)$. By Equation (18), we have

$$\Delta_c(t) = [\alpha_c(O) - \alpha_c(I)] + [1 - \mu(t)] [\beta_c(O) - \beta_c(I)]$$

Since $\mu'(t) < 0$, H_0 implies that $\Delta_c(t)$ is strictly increasing in t . Therefore, if $X_c^*(t_0) = I$ for $t_0 \in \{1, \dots, N\}$, then Equation (19) implies $X_c^*(t) = I$ for all $t \geq t_0$. Lemma 1 directly derives from this observation. ■

Although Lemma 1 offers a simple way to test H_0 on task-level data, such disaggregated data unfortunately are not available. In our empirical analysis, we only have access to sector-level import data. With this in mind, we now derive sufficient conditions under which one can relate H_0 to these sector-level data. We introduce the following definition.

Definition 2 *A sector s is less routine than another sector s' if*

$$\sum_{t=1}^{t_0} b^s(t) \leq \sum_{t=1}^{t_0} b^{s'}(t) \text{ for all } 1 \leq t_0 \leq T.$$

Broadly speaking, we say that a sector s is less routine than another sector s' if it is relatively more intensive in the less routine tasks. Formally, s is less routine than s' if the distribution of task intensities in s first-order stochastically dominates the distribution of task intensities in s' .¹¹ This implies that if s is less routine than s' in the sense of Definition 1, then the average routineness of tasks in sector s , $\mu^s \equiv \sum b^s(t) \mu(t)$, is lower than the average routineness of tasks in s' . Of course, the converse is not true. Hence, our notion of a sector being “less routine” is a stronger one.

Let χ_c^s denote the share of the value of imports from country c in sector s that is intrafirm.

Proposition 3 *Suppose that H_0 holds. Then for any country $c = 1, \dots, C$, the share of the value of imports that is intrafirm is higher in less routine sectors.*

¹¹Recall that $1 \geq b^s(t) \geq 0$ and $\sum_{t=1}^T b^s(t) = 1$ for all s .

Proof. Consider two sectors s and s' such that s is less routine than s' . By Lemma 1, we know that

$$\chi_c^s = \frac{\sum_{t=t_c^*+1}^T p_c(t) Y_c^s(t)}{\sum_{t=1}^T p_c(t) Y_c^s(t)}$$

where $p_c(t)$ is the price of task t in country c under free trade. By Equation (17), we can rearrange the previous expression as

$$\chi_c^s = \sum_{t=t_c^*+1}^T b^s(t) \quad (20)$$

Since $\sum_{t=1}^T b^s(t) = 1$, Definition 1 implies

$$\sum_{t=t_c^*+1}^T b^s(t) \geq \sum_{t=t_c^*+1}^T b^{s'}(t) \quad (21)$$

Equation (20) and Inequality (21) imply that for any country $c = 1, \dots, C$, the intrafirm share of import value is higher in less routine sectors. ■

Before we turn to our empirical analysis, a few comments are in order. First, as we will see in Section 2.3.3, the value of intrafirm U.S. imports is measured in practice as the total value of shipments declared by U.S. multinationals to be from “related parties.” To go from our simple theory to the data, we will make the implicit assumption that the probability that a U.S. multinational declares a shipment to be from “related parties” is monotonically increasing in the share of that shipment’s value that is intrafirm.

Second, there are no technological differences across countries. Equation (17) requires that tasks always are combined with the same technology: task intensity, $b^s(t)$, does not vary with c .¹² This feature of the model allows us to infer the task composition of U.S. imports from U.S. (rather than Foreign) data on employment across tasks.

Third, it is worth emphasizing that H_0 does *not* imply that the share of intrafirm trade should be higher in sectors with lower average routineness of tasks. To

¹²Since all tasks are assumed to be nontraded, our model also rules out the fragmentation of the production process, which may be another important source of technological differences in practice. See e.g. Feenstra and Hanson (1996) and Grossman and Rossi-Hansberg (2008) for trade models developed along those lines.

see this, consider the following example with three tasks, $t = 1, 2, 3$, and two sectors, $s = 1, 2$. Suppose that the levels of task routineness are such that $\mu(1) = 1$, $\mu(2) = 0.5$, and $\mu(3) = 0$; task intensities in sector 1 are such that $b^1(1) = 0$, $b^1(2) = 1$, and $b^1(3) = 0$; and task intensities in sector 2 are such that $b^2(1) = 0.9$, $b^2(2) = 0$, and $b^2(3) = 0.1$. By construction, the average task routineness in sector 2 (0.9) is strictly higher than the average task routineness in sector 1 (0.5). Yet, if $t_c^* = 2$, the share of intra-firm trade is strictly higher in sector 2! This is an important observation, which will be at the core of our empirical strategy. In order to test H_0 with sector level data, one needs to restrict the sample of sectors to those whose routineness can be ranked in the sense of Definition 1.

Finally, we wish to point out that the fact that any task is either always outsourced or always performed in house is not crucial for Proposition 1. In a generalized version of our model where less routine tasks are less likely to be outsourced—because of other unspecified sector characteristics—Proposition 1 would still hold.¹³

2.3 Data

To investigate empirically whether adaptation is an important determinant of the boundary of multinationals, we first need measures of: (i) routineness at the task level, $\mu(t)$; (ii) task intensity at the sector level, $b^s(t)$; and (iii) share of intrafirm trade at the sector and country level, χ_c^s .

2.3.1 Task Data

We define a task t as a 2-digit occupation in the Standard Occupational Classification (SOC) system. To measure how routine each of these tasks is, we use the U.S. Department of Labor's Occupational Information Network (O*NET). This database includes measures of the importance of more than 200 worker and occupational characteristics in about 800 6-digit occupations. Such characteristics include finger dexterity, oral

¹³This directly derives from the fact that if a distribution F first-order stochastically dominates another distribution G , then the expected value of any increasing function is higher under F than under G .

expression, thinking creatively, operating machines, general physical activities, analyzing data, and interacting with computers. In this paper, we use the importance of “making decisions and solving problems” as our index of how routine a task is. Formally, we measure the routineness $\mu(t)$ of a task t as

$$\mu(t) = 1 - \sum_{\tau} \alpha(\tau, t) P(\tau) / 100$$

where τ is a 6-digit occupation; $\alpha(\tau, t) \in [0, 1]$ is the employment share of occupations τ in task t in 2006; and $P(\tau) \in [0, 100]$ is the importance of problem solving for occupation τ in O*NET. Table 14 ranks the 17 tasks in our sample from least to most routine.

2.3.2 Sector Data

We define a sector as a 4-digit industry in the North American Industry Classification System (NAICS). Equation (16), Equation (17), and perfect competition imply

$$b^s(t) = \frac{w_c L_c^s(t)}{\sum_{t=1}^T w_c L_c^s(t)} = \frac{L_c^s(t)}{\sum_{t=1}^T L_c^s(t)} \quad (22)$$

Since task intensity, $b^s(t)$, does not vary with c , we can measure it using data on the share of employment of that 2-digit occupation in *any* country. In the rest of this paper, we use U.S. data from the Bureau of Labor Statistics Occupational Employment Statistics 2006. By Definition 1 and Equation (22), a sector s is less routine than a sector s' if and only if its distribution of employment across tasks dominates the distribution in s' in terms of first order stochastic dominance. Table 15 summarizes the 77 sectors in our sample ranked by their average routineness $\mu^s = \sum b^s(t) \mu(t)$. Asterisks denote chains of sectors that can be ranked in the sense of Definition 1.

2.3.3 Trade data

All trade data are from the U.S. Census Bureau Related Party Trade database and cover the years 2000 through 2006.¹⁴ Variables reported in this database include the

¹⁴The Bureau of Economic Analysis (BEA) also collects data on intrafirm imports in its benchmark surveys of U.S. direct investment abroad and of foreign direct investment

total value of all U.S. imports and the value of related party, or intrafirm, U.S. imports. Imports are classified as intrafirm if one of the parties owns at least 6% of the other. The data originate with a Customs form that accompanies all shipments entering the U.S. and asks for the value of the shipment and whether or not the transaction is with a related party. These data are collected at the 10-digit HS level and reported at the 2 through 6-digit level for both HS and NAICS codes. We use the 4-digit NAICS data for our baseline analysis. Table 16 gives a ranking of these sectors by share of intrafirm imports in total U.S. imports for 2006. We constrain our sample to include only the largest exporters to the U.S., comprising 99 percent of all U.S. imports. This results in a set of 55 exporters in 77 sectors over 7 years.

2.3.4 Controls

We use data on capital intensity, skill intensity, R&D intensity, relationship specificity, the distribution of firm size, and the level of intermediation to control for other known determinants of the boundary of multinationals. Data on the relative capital and skilled labor intensities of industries are from the NBER Manufacturing Database. Capital intensity is measured as the ratio of the total capital stock to total employment. Skill intensity is measured as the ratio of nonproduction workers to production workers in a given industry. As in Antras (2003), data on the ratio of research and development spending to sales are from the 1977 U.S. Federal Trade Commission (FTC) Line of Business Survey. To control for variations in the importance of relationship specific investments, we use the index developed by Nunn (2007) based on the Rauch (1999) classification. In the spirit of Yeaple (2006), we also use Compustat data on the standard

in the US. We use the Census data rather than the BEA data for several reasons. First, the Census data are publicly available. A subset of the BEA data is public, however the full dataset is restricted. Second, when reporting intrafirm trade between foreign owned multinationals and their U.S. affiliates the BEA uses the country of ownership rather than the country in which the shipment originated. This is problematic for imports by U.S. affiliates of foreign parents from other foreign affiliates of the same parent that are located in different countries. Finally, BEA conducts benchmark surveys approximately every 5 years and smaller annual surveys in non-benchmark years, with the firm size cutoff for inclusion in these surveys changing over time. However, for robustness, we also test our model using the BEA data and get similar results.

deviation of sales of firms in an industry to control for productivity dispersion within an industry. Finally, we follow Bernard, Jensen, Redding, and Schott (2008) and use the weighted average of retail and wholesale employment shares of importing firms in an industry as a control for intermediation. Table 17 gives correlations for all of the variables described above as well as sector average routineness.

2.4 Estimation and Results

2.4.1 Sign tests

Proposition 1 offers a simple way to test H_0 . For any pair of sectors, if one is less routine than the other in the sense of Definition 1, then exporter by exporter, it should have a higher share of intrafirm trade. 67 of the 77 industries in our sample exhibit stochastic dominance over at least one other sector and 67 industries are dominated by at least one other sector. Only two sectors (motor vehicles and railroad rolling stock) neither dominate nor are dominated by any other sector. Out of the 27,081 possible comparisons in our data for 2006 (pair sectors*countries), 18,002 have the right signs. In other words, in 67% of all cases, the less routine sector has a higher share of intrafirm trade. Overall, we view this first look at the data as surprisingly encouraging. Recall that Proposition 1 assumes away any other determinant of the boundary of U.S. multinationals!

Tables 18 and 19 present the results of our sign tests using 2006 data broken down by countries and sectors. Each sector-level sign test includes all observations for which a given industry is either the dominant or the dominated sector in the pair. There is a substantial amount of variation across countries. Success rates of the sign tests range from 30% in Peru to 100% in Algeria. Based on these results, there is little evidence that technological differences are a major issue for our approach. Algeria, Cambodia and China are among the most successful countries. There also is a substantial amount of variation across sectors. Success rates range from 43% for tobacco products to 86% for petroleum and coal products. The poor performance of our theory for tobacco products clearly suggests that other sector characteristics, such as capital intensity, also affect

the boundary of multinational firms. In order to address this issue, we now turn to cross-sector regressions.

2.4.2 Cross-sector regressions

We consider linear regressions of the form

$$\chi_c^s = \alpha_c + \beta\mu^s + \gamma Z^s + \varepsilon_c^s \quad (23)$$

where α_c is a country fixed effect; μ^s is the average routineness of sector s ; and Z^s is a vector of controls. Holding Z^s fixed, Proposition 1 predicts that under H_0 , less routine sectors should have a higher share of intra-firm trade.¹⁵ In other words, if we restrict ourselves to a chain of sectors that can be ranked in the sense of Definition 1, then we should observe that $\beta < 0$.¹⁶

Table 20 presents the OLS estimates of Equation (23) for the 7 industries that can be ranked in the sense of Definition 1 for all years in our sample. In order to allow for comparison across right-hand-side variables, we report beta coefficients, which have been standardized to represent the change in the intrafirm import share that results from a one standard deviation change in each independent variable. In all specifications, the OLS estimate of β is negative and statistically significant, implying that less routine sectors have a higher share of intrafirm imports. Regarding the impact of other sector characteristics, our results are consistent with the empirical findings of Antras (2003). Capital intensity and R&D intensity tend to increase the share of intrafirm trade, whereas skill intensity tends to decrease it. By contrast, in this sample of seven sectors the impact of the dispersion of firm size, relationship specificity and intermediation differ from the results of Yeaple (2006), Nunn and Trefler (2008), and Bernard, Jensen, Redding, and Schott (2008), respectively. In Section 2.5, we return to these regressions using the full set of manufacturing industries, as in the aforementioned studies. As we will see, the

¹⁵Formally, if ex ante productivity can be written as $\alpha_c(X, Z^s)$, then *ceteris paribus*, less routine sectors have a higher share of intra-firm trade.

¹⁶Recall that, in general, H_0 has no implications for the impact of μ^s on the share of intra-firm trade.

qualitative results from all of these previous studies are replicated in this case.

In terms of magnitude, the impact of routineness is larger than that of capital intensity, specificity, intermediation, and dispersion in all specifications reported in Table 20. Using the specification with the smallest coefficient on routineness as a lower bound, we find that a one standard deviation decrease in the routineness level of a sector leads to a 0.26 standard deviation increase in the share of intrafirm imports, or an additional 7% of total imports that are within firm. We view these results as strongly supportive of the main hypothesis of our paper: adaptation is an important determinant of the boundary of multinational firms.

2.5 Robustness checks

2.5.1 Alternative sample of sectors

An obvious drawback of the results presented in Section 2.4 is that they rely on a sample of only seven sectors. In order to increase the size of our sample, we now weaken the criteria under which two sectors can be ranked in the sense of Definition 1. Instead of requiring the distribution of task intensities in a given sector to dominate the distribution of task intensities in another sector for *all* years, we only require that this ranking holds for at least *one* year in our sample. The broad rationale for this alternative criterion is that the absence of dominance from one year to the next may simply be due to measurement errors in occupation shares. By following this approach, we extend our sample to ten sectors; see Table 15 for details. Our OLS estimates using this new sample are reported in Table 21. As in Section 2.4, the impact of routineness is negative, statistically significant, and larger in absolute value than the impacts of the other control variables.

As an additional robustness check, we reestimate Equation (23) using the full set of 4-digit NAICS industries. The results are presented Table 22.¹⁷ The coefficient

¹⁷In yet another robustness check, we also considered 6-digit NAICS level sectors instead of 4-digit NAICS in our regressions using the industry-level weighted average problem solving score. The results were qualitatively similar.

on routineness remains negative and statistically significant in all of these specifications. In line with our theory, the results using all manufacturing industries are not quite as strong as those using chains of sectors satisfying Definition 1. Nevertheless, the impact of routineness is still more important than capital intensity, skill intensity, specificity, intermediation and dispersion. Finally, note that unlike in previous regressions, these last results also are consistent with previous empirical findings of Yeaple (2006), Nunn and Treffer (2008), and Bernard, Jensen, Redding and Schott (2008). Productivity dispersion and relationship specificity tend to increase the share of intrafirm trade, whereas intermediation tends to decrease it.

2.5.2 Alternative sample of countries

One drawback of the Census data is that they do not distinguish between imports by U.S.-owned multinationals from their foreign affiliates and imports by U.S. affiliates of foreign-owned multinationals.¹⁸ Since our theoretical framework focuses on the former case, we also run our regressions using the restricted sample of countries proposed by Nunn and Treffer (2008). A country is included in the restricted sample if at least two-thirds of intrafirm U.S. imports from that country are imported by U.S.-owned firms. Nunn and Treffer construct this sample using data on intrafirm U.S. imports by country and parent in 1997 from Zeile (2003). The results using this restricted set of countries are presented in Table 23. In line with the results using the full sample of countries, the coefficient on routineness is negative and statistically significant in all specifications.¹⁹

¹⁸A second drawback is that we only have data on intrafirm imports relative to total imports by all U.S. firms, not relative to U.S. imports by multinationals, which would do a better job of capturing the share of inputs imported by multinationals that are intrafirm. This drawback, unfortunately, is common to both the U.S. Census and BEA data.

¹⁹We also re-run the regressions presented in Tables 21 and 22 using this restricted set of countries and obtain results that are similar to those using the full sample of countries.

2.6 Conclusion

Nonroutine activities a supplier must undertake for a multinational headquarters are more likely than routine activities to give rise to problems *ex post* the nature of which cannot be fully specified in a contract *ex ante*. A strand of the literature stretching back to Simon (1951) and Williamson (1975) that we refer to as “adaptation theories” of the firm implies that multinationals are more likely to supply nonroutine than routine activities internally. We tested this prediction using sector level data on the intrafirm imports of U.S. multinationals from the Census and occupation level data from the U.S. Department of Labor’s Occupational Information. Using both non parametric sign tests and cross-sector regressions, we found that less routine sectors tend to have a higher share of intrafirm trade. This result is robust to inclusion of other variables known to influence the U.S. intrafirm import share such as capital intensity, R&D intensity, relationship specificity, intermediation and productivity dispersion. Our most conservative estimate suggests that a one standard deviation decrease in average routineness raises the share of intrafirm imports by 0.26 standard deviations, or an additional 7% of imports that are intrafirm. To us, these results indicate that routineness is a key determinant of the boundary of multinational firms, and that “adaptation theories” of the firm merit further development and empirical application in the multinational context.

2.7 Acknowledgement

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2.8 References

- Alchian, Armen and Harold Demsetz, 1972, Production, Information Costs, and Economic Organization, *American Economic Review*, vol. 62(5), pp. 777-795.
- Antras, Pol, 2003, Firms, Contracts, And Trade Structure, *The Quarterly Journal of Economics*, vol. 118(4), pp. 1375-1418, November.
- Antras, Pol and Elhanan Helpman, 2008, Contractual Frictions and Global Sourcing, forthcoming in Helpman, E., D. Marin, and T. Verdier, *The Organization of Firms in a Global Economy*, Harvard University Press.
- Antras, Pol and Elhanan Helpman, 2004, Global Sourcing, *Journal of Political Economy*, vol. 112(3), ppp. 552-580, June.
- Antras, Pol and Esteban Rossi-Hansberg, 2008, Organizations and Trade, NBER Working Papers 14262.
- Arrow, Kenneth J., 1974, Limited Knowledge and Economic Analysis, *American Economic Review*, vol. 64(1), pp. 1-10, March.
- Autor, David H., Frank Levy and Richard J. Murnane, 2003, The Skill Content Of Recent Technological Change: An Empirical Exploration, *The Quarterly Journal of Economics*, vol. 118(4), pp. 1279-1333, November.
- Azoulay, Pierre, 2004, Capturing Knowledge within and across Firm Boundaries: Evidence from Clinical Development, *American Economic Review*, vol. 94(5), pp. 1591-1612, December.
- Bajari, Patrick and Steven Tadelis, 2001, Incentives versus Transaction Costs: A Theory of Procurement Contracts, *The RAND Journal of Economics*, vol. 32(3), pp. 387-407, Autumn.
- Bernard, Andrew, J. Bradford Jensen, Stephen J. Redding and Peter K. Schott, 2008, Intra-Firm Trade and Product Contractibility, Working Paper.
- Blinder, Alan S., 2007, How Many U.S. Jobs Might Be Offshorable?, Working Papers 60, Princeton University, Center for Economic Policy Studies.
- Carluccio, Juan and Thibault Fally, 2008, Global Sourcing under Imperfect Capital Markets, Working Paper, Paris School of Economics.
- Carr, David L., Markusen, James R., and Maskus, Keith E. 2001, Estimating the Knowledge-Capital Model of the Multinational Enterprise. *American Economic Review*, vol 91(3), pp. 693-708.
- Cremer, Jacques, Luis Garicano and Andrea Prat, 2007, Language and the Theory of the Firm, *The Quarterly Journal of Economics*, vol. 122(1), pp. 373-407, 02.

- Defever, Fabrice and Farid Toubal, 2007, Productivity and the Sourcing Modes of Multinational Firms: Evidence from French Firm-Level Data. Mimeo University of Paris.
- Ethier, Wilfred J, 1986, The Multinational Firm, *The Quarterly Journal of Economics*, vol. 101(4), pp. 805-33, November.
- Feenstra, Robert and Gordon Hanson, 1996, Globalization, Outsourcing, and Wage Inequality, *American Economic Review Papers and Proceedings*, vol. 86(1996): pp. 240-245.
- Feenstra, Robert C., and Gordon H. Hanson, 2005, Ownership and Control in Outsourcing to China: Estimating the Property Rights Theory of the Firm, *Quarterly Journal of Economics*, 120(2): pp. 729-762.
- Forbes, Silke and Mara Lederman, 2008, Adaptation and Vertical Integration in the Airline Industry. Working Paper.
- Gibbons, Robert, 2005, Four formal(izable) theories of the firm? *Journal of Economic Behavior and Organization*, vol. 58(2), pp. 200-245, October.
- Grossman, Gene and Esteban Rossi-Hansberg, 2008, Trading Tasks: A Simple Theory of Offshoring *American Economic Review*, forthcoming.
- Grossman, Sanford J and Hart, Oliver D, 1986, The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration, *Journal of Political Economy*, vol. 94(4), pp. 691-719, August.
- Helpman, Elhanan, 2006, Trade, FDI and the Organization of Firms, *Journal of Economic Literature*, 44, pp.589-630.
- Holmstrom, Bengt, 1982, Moral Hazard in Teams, *Bell Journal of Economics*, vol. 13(2), pp. 324-340, Autumn.
- Jensen, J. B. and L. Kletzer, 2007, Measuring Tradable Services and the Task Content of Offshorable Services Jobs In K. Abraham, M. Harper and J. Spletzer, eds., *Labor in the New Economy*, University of Chicago Press.
- Markusen, James R, 1995, The Boundaries of Multinational Enterprises and the Theory of International Trade, *Journal of Economic Perspectives*, vol. 9(2), pp. 169-89, Spring.
- Nathan Nunn, 2007, Relationship-Specificity, Incomplete Contracts, and the Pattern of Trade, *The Quarterly Journal of Economics*, vol. 122(2), pp. 569-600.
- Nunn, Nathan and Daniel Treffer, 2008, The Boundaries of the Multinational Firm: An Empirical Analysis, forthcoming in E. Helpman, D. Marin, and T. Verdier (eds.), *The Organization of Firms in a Global Economy*, Harvard University Press.
- Rauch, James E., 1999, Networks versus markets in international trade, *Journal of International Economics*, vol. 48(1), pp. 7-35, June.

- Simon, Herbert A., 1951, A Formal Theory of the Employment Relationship, *Econometrica*, vol. 19(3), pp. 293-305, July.
- Tadelis, Steven, 2002, Complexity, Flexibility, and the Make-or-Buy Decision , *American Economic Review Papers and Proceedings*, 92(2) pp. 433-437, January.
- Tomiura, Eiichi, 2007, Foreign Outsourcing, Exporting, and FDI: A Productivity Comparison at the Firm Level, *Journal of International Economics*, Vol. 72, pp. 113-127.
- Williamson, Oliver E., 1985, *The Economic Institutions of Capitalism : Firms, Markets, Relational Contracting*. New York: Free Press; London: Collier Macmillan.
- Williamson, Oliver E., 1975, *Markets and Hierarchies*. New York: Free Press.
- Yeaple, Stephen Ross. 2003, The Role of Skill Endowments in the Structure of U.S. Outward Foreign Direct Investment. *Review of Economics and Statistics*, vol. 85(3), pp. 726-734.
- Yeaple, Stephen Ross, 2006, Offshoring, Foreign Direct Investment, and the Structure of U.S. Trade, *Journal of the European Economic Association*, vol. 4(2-3), pp. 602-611.
- Zeile, William J. , 2003, Trade in Goods Within Multinational Companies: Survey-Based Data and Findings for the United States of America, BEA Papers 0022, Bureau of Economic Analysis.

3 The Role of FDI in Increasing Trade Flows

3.1 Introduction

FDI and exports may be complements rather than substitutes (see for example Markusen 1997 or Amiti and Wakelin 2003). We may also expect these complementarities to be stronger for services than for manufactures. Service industries, on average, rely more heavily on interactive tasks such as working directly with final consumers than manufacturing industries. These interactive tasks are also significantly associated with increased FDI sales (see Oldenski 2009). To the extent that tasks can be fragmented in the production of output of a single service industry, a physical presence may be more likely to increase trade volumes in industries requiring direct interaction with consumers. In other words, if trade is costly in a given industry because of problems resulting from the physical separation of producers and consumers, then establishing a physical FDI presence in the destination market could alleviate those problems and allow for greater exports.

Table 24 shows correlations between the existence of FDI and the existence of exports broken down by goods and services. The correlation between the existence of FDI sales and the existence of exports is 0.42 for services and 0.28 for goods. In service industries for which exports comprise at least 10 percent of foreign sales, the correlation is 0.45, suggesting that the association between FDI and exporting is greater for services than for manufacturing. Table 25 presents the results of a simple OLS regression of the existence of exports on FDI at the country-industry level, run separately for manufacturing versus service industries. The correlation is significant for both samples, however the magnitude of the coefficient on FDI is much larger for services than for manufacturing. An OLS approach is problematic for estimating the role of FDI in increasing exports due to the endogeneity of exports and FDI. The coefficients in Table 25 should not be interpreted causally, but rather give preliminary suggestive evidence that complementarities between exporting and FDI may be stronger for services relative to manufacturing

industries.

In this paper, I address the potential endogeneity of exports and FDI by instrumenting for FDI using restrictions on investment that were in place prior to the sample period and find that increased FDI by U.S. multinational companies in a given industry significantly increase U.S. exports to the countries receiving those flows. This result holds for horizontal FDI and exports of final services rather than just vertical FDI and exports of intermediates. I also present evidence that the complementarity between exports and FDI is stronger for service industries than it is for manufacturing by using the existence of bilateral investment treaties at the country level as an instrument and estimating the relationship on separate samples of manufacturing and services.

3.2 Related Literature

An extensive literature looks at the decision of firms to serve foreign markets by producing at home for export or by locating production in the destination market through FDI. Brainard (1993, 1997) frames this decision as a trade off between the high marginal costs of exporting and the high fixed costs of duplicating production through FDI. Helpman, Melitz and Yeaple (2004) introduce heterogeneous firms into this framework, but retain the assumption that exports and FDI are substitutes. A few papers have considered the possible complementarities between trade and investment. Markusen (1997) simulates trade liberalization, investment liberalization, and simultaneous liberalization of both trade and investment. His results show that trade and investment liberalizations alone have very different effects on optimal firm structure and that together they function as complements in a welfare sense. Focusing on relationships between developed and developing countries, his results suggest that a reduction in both trade and investment barriers encourages the formation of vertical multinationals, in which more skill-abundant countries specialize in headquarters services and less skill-abundant countries specialize in production. Amiti and Wakelin (2003) test the impact of investment liberalization on trade flows and find that investment liberalization stimulates exports when countries differ in relative factor endowments and trade costs are low (e.g. vertical

motives for FDI dominate), yet substitutes for exports when countries differ in size and trade costs are high (e.g. horizontal motives for FDI dominate). Antras and Foley (2009) consider a different source of complementarities, showing that regional trade liberalization can increase FDI from countries outside the region of liberalization. A few other studies, including Blomstrom, Lipsey and Kuchtcky (1988), Lipsey and Weiss (1981), and Blonigen (2001), have found evidence of both complementarities and substitution between FDI and exports. I am not aware of any research looking specifically at these complementarities for service industries.

3.3 Theoretical Framework

The theoretical framework follows Helpman, Melitz and Yeaple (2004). They develop a model in which heterogeneous firms serving foreign markets choose between producing at home for export or producing in the destination market through FDI. In their model, the profits from exporting from country i to country j are:

$$\pi_x^{ij} = (\tau^{ij}a)^{1-\varepsilon}B^j - f_x \quad (24)$$

and the additional profits from FDI are

$$\pi_I^{ij} = (a)^{1-\varepsilon}B^j - f_I \quad (25)$$

where τ^{ij} captures trade costs, a is the firm-level productivity parameter, ε is the elasticity of substitution, B^j captures demand, and f_x and f_I are the fixed costs of exporting and FDI. Firms maximize profits, trading off the high fixed costs of FDI ($f_I > f_x$) with the high marginal cost of exporting (τ^{ij}). Assuming that the firm-level productivity, a , is drawn randomly from a pareto distribution allows them to determine ex-ante which share of sales within an industry will be through exports and which will be through FDI. Helpman, Melitz and Yeaple use this result to estimate the log ratio of sales through export to sales through FDI for each country-industry pair as a function of the fixed costs of FDI relative to exports (proxied by country fixed-effects), trade costs, and the

dispersion of firm-level productivity within the industry.

In the Helpman, Melitz and Yeaple model, marginal trade costs are independent of whether or not a firm has incurred the fixed costs of FDI. For this exercise, I modify their framework by allowing for the existence of an FDI presence to reduce marginal transport costs. An FDI presence is likely to reduce export costs, and it's likely to do so to a greater degree for services than for manufacturing industries. Tables 24 and 25 give some preliminary suggestive evidence that this is likely the case. Oldenski (2009) shows that the need for producers to interact directly with consumers is a strong deterrent to exports of both services and manufactures, and the overall effect on service trade is much greater due to the greater importance of this type of interaction in services relative to manufactures. To the extent that producers are able to separate tasks within the production process, locating the interactive tasks near consumers through FDI would allow for greater exports of the non-interactive tasks. This reduces the cost of exporting. For example, consider a consulting firm whose tasks include meeting with clients and performing analytical work. Without an FDI presence, meeting with clients would require sending a US-based consultant to the destination country for the meeting. Once an FDI presence is established, consultants based in the destination market can perform the interactive task of face-to-face meetings, saving the marginal transport cost of flying someone out from the US. This raises the profitability of analytical tasks that are performed in the U.S. and then exported, increasing both exports and FDI sales. In this example, the face to face meeting services would be recorded as an export if they were performed by a resident of the US and as FDI sales if they were performed by a resident of the host country.

Thus the profits from exporting can be written as

$$\pi_x^{ij} = (\psi^{ij} \tau^{ij} a)^{1-\varepsilon} B^j - f_x \quad (26)$$

where

$$\psi^{ij} = \psi^{ij}(f_I) \quad (27)$$

And the additional profits from FDI are

$$\pi_I^{ij} = (a)^{1-\varepsilon} B^j - f_I \quad (28)$$

The volume of exports is a function of whether or not the firm has an FDI presence as well as firm-level heterogeneity and the fixed and marginal costs associated with exporting.

Figure 3 shows a graph of the original profit equations from the Helpman, Melitz and Yeaple model. Note that all firms with non-zero production sell to the domestic market, incurring the fixed cost of domestic production, f_d , and earning profits π_d . Firms with productivity levels high enough to overcome the costs of exporting have sales through exports in addition to sales to the domestic market. And firms for whom FDI is profitable have sales in the domestic market, sales through exports, and sales through FDI. In my version of this model, presented in Figure 4, the slope of the profit function for exporters becomes steeper once the cutoff for FDI has been reached. This is because the physical FDI presence allows for separation of tasks within an industry. Because data is collected at the industry level, this lowers the marginal trade (or transport) costs at the industry level.

From these profit equations, the cutoff for exporting can be written as:

$$(\psi^{ij} \tau^{ij} a_x)^{1-\varepsilon} B^j = f_x \quad (29)$$

and the cutoff for FDI can be written as:

$$[1 - (\psi^{ij} \tau^{ij})^{1-\varepsilon} (a_I)^{1-\varepsilon}] B^j = (f_I - f_x) \quad (30)$$

The firm will choose to export where $\pi_x - \pi_I > 0$ and produce abroad through FDI

where $\pi_x - \pi_I < 0$. Thus the ratio of exports, X , to FDI, I is

$$\frac{X^{ij}}{I^{ij}} = (\psi^{ij}\tau^{ij})^{1-\varepsilon} \left[\frac{V(a_x)}{V(a_I)} - 1 \right] \quad (31)$$

where $V(a) = \int_0^a y^{1-\varepsilon} dG(y)$ is the distribution of productivity. V is pareto with shape parameter $k - (\varepsilon - 1)$. This distribution implies that $V(a_x)/V(a_I) = (a_x/a_I)^{k-(\varepsilon-1)}$. Plugging in using the cutoff values for FDI and exporting to get a_x and a_I , this condition becomes

$$\frac{X^{ij}}{I^{ij}} = (\psi^{ij}\tau^{ij})^{1-\varepsilon} \left[\left(\frac{f_I - f_x}{f_x} \cdot \frac{1}{(\psi^{ij}\tau^{ij})^{1-\varepsilon} - 1} \right)^{\frac{k-(\varepsilon-1)}{\varepsilon-1}} - 1 \right] \quad (32)$$

However, the focus of this paper is on how FDI impacts exports, not on the export to FDI ratio. To get the volume of export sales as a function of FDI, I can rewrite (32) as

$$X^{ij} = I^{ij} (\psi^{ij}\tau^{ij})^{1-\varepsilon} \left[\left(\frac{f_I - f_x}{f_x} \cdot \frac{1}{(\psi^{ij}\tau^{ij})^{1-\varepsilon} - 1} \right)^{\frac{k-(\varepsilon-1)}{\varepsilon-1}} - 1 \right] \quad (33)$$

Log linearizing (33) gives

$$\ln X^{ij} = \ln I^{ij} + (1 - \varepsilon) \ln \psi^{ij} + (1 - \varepsilon) \ln \tau^{ij} + \left(\frac{k - (\varepsilon - 1)}{\varepsilon - 1} \right) \ln \left(\frac{f_I - f_x}{f_x} \right) + \xi \quad (34)$$

Where

$$\xi = (k - (\varepsilon - 1)) \left(\frac{(\psi^{ij}\tau^{ij})^{1-\varepsilon}}{(\psi^{ij}\tau^{ij})^{1-\varepsilon} - 1} \right) \ln \psi^{ij} + (k - (\varepsilon - 1)) \left(\frac{(\psi^{ij}\tau^{ij})^{1-\varepsilon}}{(\psi^{ij}\tau^{ij})^{1-\varepsilon} - 1} \right) \ln \tau^{ij} \quad (35)$$

Due to this nonlinearity of this equation, I will estimate a reduced-form version of (34) to test whether the data are consistent with the complementarities implied by (33), rather than interpreting the coefficients structurally. The estimating equation is:

$$\ln(X_h^{ij}) = \beta_0 I_h^{ij} + \beta_1 \psi_h^{ij} + \beta_2 \tau_h^{ij} + \beta_3 k_h + \beta_4 \delta_h + \beta_5 \delta_h^{ij} + e_{zi} \quad (36)$$

Where h indexes industries, δ_h is a vector of industry-level controls and δ^{ij} is a vector of country-level controls. A simple OLS regression of equation (13) is problematic, however, as we would expect exports and FDI sales to be jointly determined by a number of common factors, such as GDP, distance, language, etc. To get around this problem, I use industry-specific service FDI restrictions that were in place in 1993 from the OECD Code of Liberalization of Capital Movements as an instrument for FDI. I chose 1993 because it occurs before the earliest year of the service export and FDI data. Using data from 1993 also avoids the potential endogeneity of commitments negotiated in the General Agreement on Trade in Services (GATS), which took effect in 1995. Because the GATS negotiations involved simultaneous liberalization of both trade and investment barriers, restrictions on service FDI during this period are likely to be problematic as an instrument. Restrictions on FDI are a measure of investment costs rather than of FDI itself and are therefore less likely to be endogenous to exports, particularly for investment costs that were in place before the period covered by the export data.²⁰ Table 26 shows that the 1993 OECD restrictions do not exert an independent causal effect on exports occurring during the 1994 to 2004 time period. Because the same factors that determine the level of exports are similar to those that determine whether exports take non-zero values, I test the model using a dummy variable for exports in addition to the log export volume.

The OECD data are useful for estimating the impact of FDI on exports for service industries because they are collected at the country and industry level. However, because these data are only available for services, they do not allow for a comparison of the extent to which exports and FDI are complements in manufacturing relative to service industries. I am not aware of an industry and country level measure of FDI

²⁰Amiti and Wakelin (2003) make a similar argument for their use of a different investment cost measure.

barriers for manufacturing. To compare manufacturing and services, I instead use a dummy variable indicating whether or not the U.S. has signed a bilateral investment treaty (BIT) with the destination country. This measure varies only by country, not by industry, but is likely to impact investment in both manufacturing and services. I use these BITs as an instrument to estimate the impact of FDI on the total volume of exports to a given country separately for manufacturing versus service industries.

3.4 Data

Data on FDI are from The Bureau of Economic Analysis. BEA collects firm-level data on U.S. multinational company operations in both goods-producing and service-producing industries in its benchmark surveys of U.S. direct investment abroad. I use these data to define the measures of FDI used in this paper. Sales by foreign affiliates of U.S. parent firms to the local market capture the volume of horizontal FDI. Total sales by affiliates (including sales to the local market, sales to the US, and sales to other countries) capture the total volume of FDI. I also include dummy variables indicating whether or not any U.S. affiliates are present in the foreign country in a given industry and whether or not any sales to the local market (horizontal FDI) exist.

The information on manufacturing firms contained in this dataset has been used in previous studies (see for example Hanson, Mataloni, and Slaughter 2005 or Desai, Foley and Hines 2001), however the data on service trade and investment are not frequently exploited (see Jensen and Mann (2007) for an exception). I restrict my sample to the years in which the Benchmark surveys were conducted, and for which data on service exports are also available. These include 1994, 1999, and 2004. The BEA surveys cover 33 service industries, classified according to BEA versions of 3-digit SIC codes.

Data on exports of services were taken from BEA's survey of selected services transactions with unaffiliated foreign persons. This survey provides information on both the general product categories that are being traded and on the primary industry of the exporting firm, as reported by the firm itself. These classifications are highly correlated (e.g. we observe firms in the legal industry exporting legal services and firms in the

advertising industry exporting advertising services). I use the industry of the exporting firm, rather than the product category, to classify service exports, as these codes are also used in the FDI data. Data from this survey are available annually beginning in 1992, resulting in a final dataset containing three years (1994, 1999, and 2004).

There are a few key differences between the public versions of the BEA services trade data and the confidential BEA survey data I use for this paper. Based on BEA definitions, service exports reported in the public data occur when “the residents of one country sell services to the residents of another country.” (Nephew et al. 2005). This could occur in the U.S. (e.g. a foreign resident travels to the U.S. to purchase services) or abroad (a company located in the U.S. provides services to an individual or company located in another country). These exports can be within firm or unaffiliated. They include services that are classified by BEA as “other private services.” These do not include travel, transportation, retail, or wholesale services. The largest categories are financial and business services, the latter of which includes information, management, telecommunications, legal, accounting, engineering, advertising, and other similar services. For this paper, I use firm-level data from BEA’s survey of selected services transactions with unaffiliated foreign persons, which is one component of the aggregate public data (compiled by BEA from several different sources). This survey covers a subset of other private service and only includes exports by U.S. companies to unaffiliated persons abroad.

Because services can not be physically tracked in the same way as goods, one might expect that the difference between exports and FDI sales might be less clear for services than for manufactures. However, the BEA has very clear guidelines for the classification of service sales as exports or FDI. This distinction is based primarily on the residence of the service provider. Consider, for example, accounting services. If a citizen of China has their taxes prepared by an accountant residing in the US, this is recorded as a service export. If instead the Chinese citizen has their taxes prepared by someone based out of a branch of a US-owned accounting firm in Beijing, then the

provision of this service is recorded as a sale through FDI.

I use industry-specific service FDI restrictions outlined in the 1993 OECD Code of Liberalisation of Capital Movements to capture investment costs.²¹ As mentioned above, 1993 was chosen because it captures restrictions that were in place before the period of the export data. I am also concerned about the potential endogeneity of commitments negotiated in the General Agreement on Trade in Services (GATS), which took effect in 1995. Because WTO countries were under pressure to liberalize FDI restrictions in some service industries, but had flexibility to decide which specific industries to liberalize, these commitments are not likely to be exogenous. They were also coupled with a lifting of restrictions on imports of services, again confounding the causal relationship between FDI and trade. The 1993 OECD data have two main drawbacks. First, they are only available for 23 countries. Second, they are only available for service industries and therefore do not allow a comparison of the degree of export-FDI complementarity between manufacturing and service industries. However, the usefulness of this instrument in empirically identifying the role of FDI in facilitating exports outweighs its limitations in terms of the number of countries and industries studied. Moreover, the fact that coefficients can be precisely estimated with a relatively small sample of countries and industries further reinforces the power of the instrument.

To estimate the difference in the level of complementarity across manufacturing versus services, I use data on bilateral investment treaties (BITs) from the United Nations Conference on Trade and Development (UNCTAD). These data indicate whether or not the U.S. has an agreement with each country for “the reciprocal encouragement, promotion and protection of investments in each other’s territories by companies based in either country.” UNCTAD compiles a list of countries who have signed these agreements based on the electronic versions of BITs made available by a number of countries on their official websites, as well as the printed versions available from official national and

²¹More recent versions of the OECD Code of Liberalization of Capital Movements have been used by Golub et al. (2003) to create similar classifications of service FDI restrictions

international collections and publications.

I also use data from a variety of other sources to construct control variables. The great circle distance between capital cities proxies for transport costs. GDP is used to capture market size. Data on firm-level sales by industry from Compustat are used to construct a measure of productivity dispersion for each industry in the sample. Relative wages in manufacturing and services are constructed using data from Freeman and Oostendorp (2000). The linguistic distance between countries based on language trees from Fearon (2003) is used to capture the effect of language. The more nodes on these trees that two languages have in common, the more likely they are to trace their roots to a recent common ancestor language. In this sense, the number of common nodes (out of a possible total of 15) that two languages share can be used to measure their linguistic similarity. Fearon (2003) also provides information on the linguistic composition of countries. Combining the information on language trees with the linguistic composition of countries results in a linguistic distance measure for each country, which is bounded by 0 and 1 and increasing in linguistic distance. I also use measures of the intensity with which each industry uses nonroutine and communication intensive tasks (see Oldenski 2009 for a detailed description of how these measures are constructed).

3.5 Empirical Specification and Results

Table 26 shows that the 1993 service FDI restrictions are not endogenous to either the level or existence of service exports for 1994 through 2004. For the two-stage least squares estimates, I use these restrictions to instrument for two different types of FDI. The first is horizontal FDI, measured by the sales of foreign affiliates of U.S. multinationals to the local market. The second measure, total sales by each affiliate, captures the overall level of FDI, rather than just horizontal FDI sales. The results using these two measures are very similar. For each definition of FDI, I also construct a dummy variable. The first dummy captures whether any horizontal FDI sales exist for a given country-industry-year. The second dummy captures whether there is any

FDI presence at all, regardless of whether or not horizontal sales are recorded. Table 27 presents the first stage results using each of these definitions of FDI. The results show that the OECD measure of FDI restrictions is a significant predictor of the both FDI sales and FDI presence during the sample period. The OECD93 variable indicates whether or not restrictions are in place, so the negative coefficients are consistent with these restrictions preventing FDI.

Tables 28 through 31 present the second stage results using the 1993 FDI restrictions as an instrument for FDI. Tables 28 and 29 include a number of country and industry characteristics that may potentially impact exports. Tables 30 and 31 present results using country and industry fixed effects in place of these controls. In these specifications, both the existence of FDI sales and the log level of FDI sales are significantly associated with an increase in service exports. These results suggest that a physical FDI presence serves to facilitate exports above and beyond any common factors causing both export and FDI sales.

I am also interested in the extent to which the complementarity between exports and FDI may be stronger for services than for manufactures. It is not possible to make this comparison using the OECD instruments because those data are only available for service industries. Instead, I use a variable indicating whether or not the U.S. has signed a bilateral investment treaty (BIT) with the destination country. For this exercise, I aggregate the export and FDI data up to the country level for two broad sectors: manufacturing and services. Table 32 shows that BITs do not exert an independent influence on either the volume or existence of exports to a given country. From Table 32, we also see that, at this level of aggregation, there are only four observations for which exports take a zero value. For this reason, I focus on the impact of FDI on export volumes, rather than on the export dummy.

Table 33 presents the first stage results for the BITs instrument. The impact of these treaties on the existence of FDI is more precisely estimated than the impact on the volume of FDI, however all specifications yield a positive and significant relation-

ship. Table 34 gives the second stage results using BITs as an instrument for horizontal FDI. In column 1, the positive and significant coefficient on FDI sales, instrumented for using BITs, suggests that higher volumes of FDI are associated with increased exports. Column 2 presents these results using only the service sector and column 3 only uses manufactures. Although the coefficients are positive for both sectors, the coefficient is both larger and more precisely estimated for services, suggesting that the complementarity between exports and FDI is stronger for services than it is for manufacturing. There could potentially be some concern that the difference in these results is due to a difference in the countries with which the U.S. trades goods versus services. However, the sample of countries for which for which the BITs data are available is small enough and the industries are aggregate enough the the sets of countries are almost identical, and thus so are the BITs instruments used, for both manufacturing and service industries. Similar results are presented for the existence of an FDI presence in columns 4-6. In this case, having an FDI presence in a country exerts a positive and significant impact on U.S. exports of services to that country. However, the presence of multinational affiliates has no significant effect on U.S. exports of manufactured goods. Table 35 shows that these results hold for either definition of investment: total FDI or horizontal FDI.

3.6 Conclusion

Many models assume that exports and FDI sales are substitutes in a firm's decision of how to serve foreign markets. In this paper, I have shown that they may actually be complements, even for horizontal sales, and that the complementarity is stronger for services than for manufacturing industries. One potential explanation for this complementarity may be that the production of certain services includes tasks that require direct interaction between producers and consumers, raising the cost of exports. Once an FDI presence has been established, however, these interactive tasks can be performed by the affiliates in the destination market, lowering the cost of exporting. In this paper, I present evidence that an FDI presence increases exports of services, however I leave more detailed examinations of the channels through which these complementarities

operate as a subject for future research.

3.7 References

- Amiti, Mary and Katharine Wakelin, 2003, Investment liberalization and international trade. *Journal of International Economics*, 61(1), pp. 101-126
- Antras, Pol and C. Fritz Foley, 2009, Regional Trade Integration and Multinational Firm Strategies. Working Paper.
- Bloomstrom, Magnus, Robert Lipsey and Ksenia Kulchycky, 1988, U.S. and Swedish Direct Investment and Exports, in Baldwin, Richard, ed. *Trade Policy Issues and Empirical Analysis*, University of Chicago Press, pp.259-297.
- Blonigen, Bruce, 2001, In search of substitution between foreign production and exports, *Journal of International Economics*, 53(1), pp. 81-104.
- Brainard, Lael, 1997, An Empirical Assessment of the Proximity-Concentration Trade-off between Multinational Sales and Trade. *American Economic Review*, 87, pp. 520-544.
- Brainard, Lael, 1993, A Simple Theory of Multinational Corporations an Trade with a Trade-off between Proximity and Concentration. National Bureau of Economic Research Working Paper No. 4269.
- Desai, Mihir, Fritz Foley and James Hines Jr., 2001, Repatriation Taxes and Dividend Distortions, *National Tax Journal*, 54, pp. 829-851.
- Fearon, James, 2003, Ethnic and Cultural Diversity by Country. *Journal Journal of Economic Growth*, 8(2), pp. 195-222
- Freeman, Richard B. and Remco Oostendorp, 2000, Wages Around the World: Pay Across Occupations and Countries. NBER Working Paper No. W8058.
- Golub, Steve, Dana Hajkova, Daniel Mirza, Giuseppe Nicoletti and Kwang-Yeol Yoo, 2003. Policies and International Integration: Influences on Trade and Foreign Direct Investment, OECD Economics Department Working Papers 359, OECD Economics Department.
- Hanson, G, R. Mataloni, Jr. and M. Slaughter, 2005, Vertical Production Networks in Multinational Firms. *Review of Economics and Statistics*, 87(4), pp.664-678.
- Head, Keith and John Ries, 2001, Overseas Investment and Firm Exports, *Review of International Economics*, 9(1), pp. 108-122.

- Helpman, Elhanan, Marc Melitz and Stephen Yeaple, 2004, Export versus FDI with heterogeneous firms. *American Economic Review*, 94, pp. 300-16.
- Jensen, J. Bradford and Catherine Mann, 2007, Vertical Integration in Services at U.S. Multinational Firms. Working paper prepared for the Deutsche Bundesbank/NBER Workshop on Microdata-Based Research on FDI.
- Lipsey, Robert and Merle Weiss, 1981, Foreign production and exports in manufacturing industries, *Review of Economics and Statistics*, 63, pp. 488-94.
- Markusen, James, 1997. Trade versus Investment Liberalization, NBER Working Papers 6231, National Bureau of Economic Research, Inc.
- Nephew, Erin, Jennifer Koncz, Maria Borga, and Michael Mann, 2005, US International Services: Cross-Border Trade in 2004 and Sales Through Affiliates in 2003, *Survey of Current Business* 85 (October 2005), pp. 25-77.
- Oldenski, Lindsay, 2009, Export Versus FDI: A Task-Based Framework for Comparing Manufacturing and Services, Working Paper.

Table 1: Mean Task Intensities for Manufacturing and Service Industries

Task	Goods		Services		Difference	
	raw	scaled	raw	scaled	raw	scaled
1 Working with the public	21.3	1.34	50.3	2.56	29.0	1.22
2 Creative Thinking	35.7	2.19	49.3	2.63	13.6	0.44
3 Problem solving/ decisions	54.4	3.30	66.5	3.51	12.1	0.21
4 Handling objects	62.5	3.67	35.0	1.76	-27.5	-1.91
5 Operating machines	61.0	3.59	31.7	1.65	-29.3	-1.94

Raw scores are unadjusted importance levels of each task reported by O*NET.

Scaled scores are the percentage shares of each task in the total task input requirements of a given industry.

Table 2: Mean Task Intensities for Manufacturing and Service Industries

	Task	Manufacturing	Services	Difference
1	Work w/ the public	1.34	2.56	1.22
2	Work w/ computers	2.25	3.39	1.13
3	Interpersonal	2.75	3.58	0.83
4	Conflict resolution	1.80	2.56	0.76
5	Admin tasks	1.85	2.56	0.71
6	Selling	1.28	1.91	0.63
7	Interpreting	2.03	2.61	0.59
8	Develop Objectives	1.74	2.22	0.47
9	Creative Thinking	2.19	2.63	0.44
10	Scheduling	2.03	2.47	0.44
11	Organizing work	2.90	3.32	0.42
12	Caring for others	1.70	2.12	0.42
13	Building teams	1.86	2.26	0.40
14	Updating knowledge	2.91	3.27	0.36
15	Comm inside org	3.47	3.82	0.36
16	Document info	2.82	3.17	0.35
17	Consulting/advice	1.67	2.02	0.34
18	Staffing	0.88	1.17	0.28
19	Monitor resources	1.50	1.78	0.27
20	Guide subordinates	1.68	1.90	0.22
21	Coaching	1.83	2.05	0.22
22	Problem solving	3.30	3.51	0.21
23	Process info	2.93	3.15	0.21
24	Coordinate others	2.19	2.38	0.19
25	Teaching/training	2.09	2.26	0.18
26	Analyzing data	2.69	2.82	0.13
27	Getting information	4.28	4.14	-0.14
28	Identifying objects	3.66	3.31	-0.35
29	Estimate/quantify	2.65	2.27	-0.38
30	Evaluate compliance	3.35	2.90	-0.45
31	Repair elec equip	1.51	0.94	-0.57
32	Draft technical	1.54	0.92	-0.62
33	Monitor processes	3.75	2.89	-0.86
34	Inspecting	3.64	2.22	-1.41
35	Physical activities	3.31	1.79	-1.51
36	Repair mechanical equip	2.53	0.88	-1.65
37	Handling objects	3.67	1.76	-1.91
38	Operating machines	3.59	1.65	-1.94

Table 3: US Exports of Services*

Service Category	2004 US Exports (\$M)	2004 Share of US Service Exports
Financial services	32,666	22%
Education and Training	13,634	9%
Insurance	7,314	5%
Telecommunications	4,651	3%
Business/professional		
Computer and information	8,800	6%
Research and development	8,688	6%
Management and consulting	5,339	4%
Other business/professional	48,962	33%
Other services	18,095	12%
Total	148,149	100%

*constructed using publicly available data from www.bea.gov

Table 4: Service Industries Ranked from Highest to Lowest Export/FDI Ratio

- 1 Legal services
- 2 Accounting, auditing, and bookkeeping services
- 3 Communications (other than telegraph and telephone)
- 4 Amusement and recreation
- 5 Research, development, and testing
- 6 Information retrieval services
- 7 Educational services
- 8 Repair Services
- 9 Engineering, architectural, and surveying services
- 10 Management and public relations services
- 11 Telephone and telegraph communications
- 12 Business services
- 13 Equipment rental
- 14 Computer related
- 15 Other insurance
- 16 Other services
- 17 Hotels and other lodging places
- 18 Computer processing and data preparation
- 19 Advertising
- 20 Other finance, including security and commodity br.
- 21 Health services
- 22 Real estate
- 23 Motion pictures, including television tape and film
- 24 Life insurance
- 25 Accident and health insurance
- 26 Depository Institutions
- 27 Savings institutions and credit unions
- 28 Holding companies
- 29 Services to buildings
- 30 Personnel supply services
- 31 Automotive rental and leasing
- 32 Automotive parking, repair, and other services

Table 5: Correlations

	ln x	ln fdi	ln x/fdi	ln dist	ln gdp	inst	lang	lit
ln x	1							
ln fdi	0.302	1						
ln x/fdi	0.618	-0.563	1					
ln dist	-0.197	-0.211	0.003	1				
ln gdp	0.332	0.370	-0.017	-0.215	1			
institutions	0.018	-0.008	0.022	-0.304	-0.166	1		
lang dist	-0.069	-0.247	0.144	0.427	-0.223	-0.268	1	
litteracy	0.048	0.160	-0.090	-0.204	0.155	0.294	-0.412	1

	edu	nr	comm
education	1		
nonroutine	0.620	1	
communication	0.277	0.608	1

Table 6: Proximity-Concentration Model of the determinants of the export to FDI ratio, controlling for selection bias, standard errors clustered by country

Model:	1	2
Sample:	goods	svc
N :	5000	3161
Depvar:	ln(x/fdi)	ln(x/fdi)
intcpt	5.953*** (1.110)	-1.698 (1.769)
dispersion	-0.376*** (0.041)	-0.271*** (0.043)
ln gdp	-0.064* (0.029)	-0.015 (0.043)
ln distance	-0.587*** (0.057)	-0.135 (0.105)
R-sq	0.069	0.042

*,** and *** indicate significance at the 10, 5 and 1 percent levels, respectively

Table 7: Export-FDI Model, controlling for selection bias, standard errors clustered by country

Model :	1	2	3	4	5	6
Sample:	goods	services	gds+svc	goods	services	gds+svc
N:	4181	2679	6860	4181	2679	6860
Depvar:	ln(x/fdi)	ln(x/fdi)	ln(x/fdi)	ln(x/fdi)	ln(x/fdi)	ln(x/fdi)
intcpt	-6.303*** (1.842)	-8.702** (3.465)	-4.048*** (1.350)	2.665* (1.477)	1.093 (2.227)	1.592 (1.048)
dispers	-0.396*** (0.045)	-0.292*** (0.047)	-0.341*** (0.033)	-0.472*** (0.043)	-0.314*** (0.050)	-0.376*** (0.033)
ln gdp	0.045 (0.030)	0.074 (0.046)	0.060** (0.025)	0.021 (0.030)	0.088* (0.046)	0.066** (0.025)
ln dist	-0.487*** (0.059)	-0.201 (0.189)	-0.374*** (0.055)	-0.481*** (0.058)	-0.196 (0.189)	-0.367*** (0.055)
lang	9.288*** (1.955)	11.263*** (3.941)	6.975*** (1.334)	2.471* (1.425)	0.600 (1.716)	2.923*** (0.657)
lit	0.878* (0.482)	-2.183** (0.790)	-0.261 (0.420)	0.849* (0.485)	-2.165*** (0.757)	-0.173 (0.419)
wage	0.292 (0.191)	-0.41 (0.280)	0.020 (0.161)	0.284 (0.191)	-0.401 (0.280)	0.041 (0.160)
tax	-0.005 (0.007)	0.001 (0.010)	-0.003 (0.006)	-0.004 (0.007)	0.000 (0.010)	-0.003 (0.006)
inst	-0.018** (0.007)	-0.035** (0.016)	-0.013** (0.005)	-0.004 (0.005)	-0.016** (0.007)	-0.011*** (0.003)
edu	0.846*** (0.182)	0.231 (0.164)	0.483*** (0.124)	1.653*** (0.165)	0.085 (0.179)	0.609*** (0.118)
nonrtne	3.080*** (0.670)	2.639** (1.075)	2.152*** (0.429)			
inst*nrtne	-0.680** (0.332)	-1.241** (0.577)	-0.484** (0.209)			
lang*nrtne	-2.655*** (0.872)	-3.187** (1.405)	-1.626*** (0.549)			
comm				-2.218*** (0.786)	-1.010** (0.416)	-0.713** (0.292)
inst*comm				0.062 (0.382)	0.739** (0.286)	0.553*** (0.147)
lang*comm				0.671 (1.038)	0.815 (0.711)	0.071 (0.372)
R-sq	0.095	0.051	0.235	0.107	0.052	0.235

*, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively

Table 8: Export-FDI Model, controlling for selection bias, standard errors clustered by country

Model :	1	2	3
Sample:	goods	services	gds+svc
N:	4181	2679	6860
Depvar:	$\ln(x/fdi)$	$\ln(x/fdi)$	$\ln(x/fdi)$
dispersion	-0.382*** (0.043)	-0.321*** (0.050)	-0.361*** (0.033)
$\ln \text{ gdp}$	-0.042 (0.031)	0.108 (0.998)	0.045 (0.039)
$\ln \text{ distance}$	-0.534*** (0.055)	-0.165 (0.107)	-0.397*** (0.053)
lang distance	7.250*** (1.941)	10.965* (5.838)	7.678*** (1.310)
literacy	-0.699 (0.575)	-1.196 (0.877)	-0.745 (0.488)
rel wage	0.113 (0.192)	-0.273 (0.285)	-0.003 (0.162)
tax difference	-0.007 (0.007)	0.001 (0.010)	-0.004 (0.006)
institutions	-0.030*** (0.006)	-0.035* (0.020)	-0.026*** (0.004)
edu (industry)	0.548*** (0.176)	0.069 (0.179)	0.305** (0.126)
nonroutine	3.792*** (0.714)	3.014** (1.234)	2.615*** (0.479)
inst*nonroutine	-1.092*** (0.310)	-0.975* (0.593)	-0.747*** (0.216)
lang*nonroutine	-3.129*** (0.961)	-3.400** (1.622)	-2.702*** (0.624)
communication	-4.164*** (0.869)	-0.635* (0.440)	-1.660*** (0.335)
inst*comm	0.052 (0.364)	-0.178 (0.310)	0.362** (0.160)
lang*comm	2.120* (1.178)	0.374 (0.831)	1.066** (0.428)
R-sq	0.145	0.055	0.245

*, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively

Table 9: Export-FDI Model with comparative advantage controls, country and industry fixed effects

Model :	1	2	3	4
Sample:	goods	services	goods	services
N:	5520	3429	5520	3429
Depvar:	$\ln(x/fdi)$	$\ln(x/fdi)$	$\ln(x/fdi)$	$\ln(x/fdi)$
inst*nonroutine	-0.007** (0.003)	-0.004** (0.002)		
lang*nonroutine	-0.584*** (0.158)	-0.485** (0.266)		
skill*nonroutine	-0.127 (0.140)	-0.033 (0.099)		
inst*communication			-0.270 (0.414)	-0.210 (0.325)
lang*communication			0.795 (0.880)	0.032 (0.740)
skill*communication			0.315 (0.262)	0.066 (0.252)
R-sq	0.422	0.251	0.418	0.252

*, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively

Table 10: Manufacturing only Export-FDI Model with comparative advantage controls, country and industry fixed effects

Model :	1	2
Sample:	goods	goods
N:	5520	5520
Depvar:	$\ln(x/fdi)$	$\ln(x/fdi)$
inst*nonroutine	0.003*** (0.000)	
lang*nonroutine	-0.554*** (0.052)	
capital intensity*endowment	0.019 (0.056)	0.009 (0.057)
skill intensity*endowment	0.082 (0.138)	0.197 (0.144)
inst*communication		0.499 (0.213)
lang*communication		1.364 (0.831)
R-sq	0.421	0.417

*, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively

Table 11: Export-FDI Model, principal components, controlling for selection bias, standard errors clustered by country

Model :	1	2	3
Sample:	goods	services	gds + svc
N:	4181	2679	6860
Depvar:	$\ln(x/fdi)$	$\ln(x/fdi)$	$\ln(x/fdi)$
dispersion	-0.429*** (0.044)	-0.349*** (0.048)	-0.368*** (0.032)
ln GDP	-0.051 (0.030)	0.090 (0.091)	0.066 (0.060)
ln distance	-0.487*** (0.094)	-0.204 (0.197)	-0.372*** (0.055)
svc/mfg wage	0.323 (0.292)	-0.392 (0.279)	0.037 (0.161)
tax difference	-0.005 (0.007)	0.000 (0.010)	-0.003 (0.006)
literacy	0.950** (0.484)	-2.113*** (0.759)	-0.229 (0.420)
lang dist	2.698*** (0.333)	4.782*** (0.867)	3.140*** (0.246)
institutions	-0.002* (0.001)	-0.007** (0.003)	-0.002* (0.001)
edu (industry)	1.121*** (0.208)	-0.237*** (0.191)	0.258* (0.140)
nonroutine principal component	0.667*** (0.152)	0.944*** (0.205)	0.447*** (0.081)
inst*nonroutine pc	-0.001 (0.001)	-0.002** (0.001)	-0.001** (0.000)
lang*nonroutine pc	-0.726*** (0.196)	-0.903*** (0.267)	-0.304*** (0.100)
R-sq	0.088	0.059	0.234

*,** and *** indicate significance at the 10, 5 and 1 percent levels, respectively

Table 12: Average task effects, controlling for selection bias, standard errors clustered by country

Model:	1	2	3
Sample:	goods	svc	gds+svc
N:	4186	2679	6865
Depvar:	$\ln(x/fdi)$	$\ln(x/fdi)$	$\ln(x/fdi)$
dispersion	-0.400*** (-0.045)	-0.294*** (0.047)	-0.340*** (0.033)
\ln distance	-0.468*** (0.059)	-0.185 (0.109)	-0.377*** (0.054)
\ln gdp	0.05 (0.03)	0.05 (0.045)	0.056** (0.025)
relative wage	0.166 (0.184)	-0.131 (0.268)	0.033 (0.153)
tax difference	-0.004 (0.007)	-0.004 (0.01)	-0.004 (0.006)
linguistic dist	3.240*** (0.278)	2.915*** (0.429)	3.096*** (0.237)
institutions	-0.003*** (0.001)	-0.004** (0.002)	-0.002** (0.001)
education	0.844*** (0.183)	0.245 (0.165)	0.480*** (0.124)
nonroutine	1.035*** (0.15)	0.340*** (0.049)	0.892*** (0.124)
communication	-1.716*** (0.162)	-0.446** (0.129)	-0.693*** (0.096)
R-sq	0.11	0.05	0.08

*, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively

Table 13: Oaxaca-Blinder decomposition of the contribution of individual elements to the total difference in predicted $\ln(X/\text{FDI})$ between manufactures and services

Share of difference explained by endowments:	
Country endowments	3%
Dispersion	-4%
Education (industry-level)	1%
Tasks Endowments	4%
Task interactions	36%
TOTAL	40%
Share of difference explained by coefficients:	
TOTAL	55%
Share of difference explained by endowments*coefficients:	
TOTAL	5%

Table 14: Ranking of Tasks from Least to Most Routine

Task	
1	Computer and mathematical
2	Protective service
3	Management
4	Healthcare
5	Architecture and engineering
6	Business and financial operations
7	Life, physical, and social sciences
8	Arts, design, entertainment, sports, and media
9	Construction and extraction
10	Installation, maintenance, and repair
11	Office and administrative support
12	Farming, fishing, and forestry
13	Production
14	Transportation and material moving
15	Sales and related occupations
16	Food preparation and serving
17	Cleaning and maintenance

Table 15: Ranking of Sectors from Lowest to Highest Average Routineness

1	Computer equipment	40	Aluminium
2	Basic chemicals	41	Nonferrous (exc alum)
3	Pharmaceuticals	42	Household appliances
4	Pulp, paper, etc.	43	Office furniture*
5	Other chemical	44	Transport equip, nesoi
6	Communications equip	45	Other fabricated metal
7	Converted paper	46	Lime & gypsum
8	Pesticides, etc.	47	Tobacco products
9	Paints & adhesives	48	Ships & boats
10	Crowns/closures/seals	49	Dairy
11	Magnetic & optical media	50	Grain & oilseed milling
12	Aerospace*	51	Boilers & containers
13	Audio & video	52	Foods, nesoi
14	Syn rubber & fibers	53	Purchased steel products
15	Engines & turbines	54	Plastics
16	Cutlery & handtools	55	Fruit & veg preserves
17	Petroleum & coal	56	Other nonmetallic
18	Medical equip & supplies	57	Architect & struct metals
19	Hardware	58	Fabrics
20	Elec equip, nesoi	59	Other textiles
21	Foundries	60	Springs & wire**
22	Clay & refractory	61	Motor vehicles
23	Semiconductors, etc.**	62	Textile furnishings
24	Cement and concrete	63	Sugar & confectionary
25	Electric lighting equipment	64	Finished fabrics*
26	Electrical equipment*	65	Fibers, yarns & threads
27	Sawmill & wood	66	Furniture, nesoi**
28	Ag & cnstrct machinery*	67	Railroad rolling stock
29	Engineered wood	68	Apparel
30	Industrial machinery	69	Bakeries & tortillas*
31	Other wood	70	Apparel accessories
32	Motor vhcle bodies	71	Glass & glass products
33	Household furniture	72	Animal foods
34	Other machinery	73	Other leather
35	Rubber	74	Leather & hide tanning
36	Iron & steel	75	Footwear
37	Beverages	76	Seafood*
38	Motor vehicle parts	77	Meat products
39	Bolts, nuts, screws, etc.		

*Chain of sectors that can be ranked in the sense of Definition 1 (Small Sample)

**Chain of sectors that can be ranked in the sense of Definition 1 (Large Sample)

Table 16: Ranking of Sectors by Share of Intrafirm Imports in 2006

Sector	Share	Sector	Share
Motor vehicles	0.92	Glass & glass products	0.35
Pharmaceuticals	0.80	Bolts, nuts, screws, etc.	0.35
Magnetic & optical media	0.71	Bakeries & tortillas	0.35
Semiconductors, etc.	0.69	Fruit & veg preserves	0.34
Transportation equip, nesoi	0.68	Converted paper	0.33
Computer equipment	0.67	Boilers & containers	0.33
Audio & video equip	0.64	Products from purchased steel	0.32
Rubber products	0.64	Cutlery & handtools	0.32
Medical equip & supplies	0.64	Cement and concrete	0.32
Electrical equipment	0.63	Aerospace	0.32
Syn rubber & fibers	0.63	Office furniture	0.29
Engines & turbines	0.61	Springs & wire	0.28
Communications equip	0.60	Electric lighting equipment	0.28
Pesticides, fertilizers, etc.	0.60	Crowns/closures/seals	0.28
Petroleum & coal	0.60	Beverages	0.28
Other chemical products	0.59	Plastics	0.27
Paints & adhesives	0.59	Grain & oilseed milling	0.27
Ag & constrect machinery	0.59	Foundries	0.27
Motor vehicle parts	0.57	Lime & gypsum	0.26
Basic chemicals	0.56	Clay & refractory	0.26
Aluminium	0.55	Architech & struct metals	0.24
Elec components, nesoi	0.50	Nonferrous (exc alum)	0.24
Railroad rolling stock	0.49	Furniture related, nesoi	0.23
Motor vhcle bodies	0.48	Other wood	0.23
Other machinery	0.46	Engineered wood	0.22
Sugar & confectionary	0.45	Other nonmetallic mineral	0.20
Pulp, paper & paperboard	0.43	Fabrics	0.20
Industrial machinery	0.42	Other textiles	0.19
Hardware	0.40	Meat prdcts & packaging	0.18
other fabricated metal	0.40	Sawmill & wood	0.18
Household appliances	0.40	Seafood	0.17
Iron & steel	0.39	Apparel	0.14
Animal foods	0.39	Apparel accessories	0.13
Tobacco products	0.38	Other leather	0.13
Dairy	0.38	Household furniture	0.12
Finished textile fabrics	0.37	Fibers, yarns & threads	0.11
Leather tanning	0.36	Textile furnishings	0.10
Ships & boats	0.36	Footwear	0.04
Foods, nesoi	0.36		

Table 17: Correlation of Sector Characteristics

	rtne	ln(K/L)	ln(S/L)	ln(RD)	spcfcty	intrmd	dsprsn
routine	1						
ln(K/L)	-0.390	1					
ln(S/L)	-0.581	0.427	1				
ln(R&D)	-0.553	0.195	0.466	1			
specificity	-0.126	-0.409	0.178	0.415	1		
intermediation	0.495	-0.485	-0.447	-0.485	-0.036	1	
dispersion	-0.183	0.470	0.279	0.194	0.0669	-0.250	1

Table 18: Sign Tests, Country by Country, 2006

Country (N^\dagger)	Sign Test	Country (N^\dagger)	Sign Test
Algeria (13)	1.00*	Jamaica (228)	0.46
Argentina (557)	0.50	Japan (581)	0.72*
Australia (567)	0.79*	Korea (581)	0.72*
Austria (501)	0.70*	Macao (134)	0.81*
Bangladesh (169)	0.67*	Malaysia (562)	0.67*
Belgium (295)	0.53*	Mexico (581)	0.64*
Brazil (580)	0.67*	Netherlands (581)	0.65*
Cambodia (60)	0.87*	Netherlands Antilles (136)	0.77*
Canada (581)	0.50	New Zealand (553)	0.43*
Chile (505)	0.52	Norway (543)	0.68*
China (581)	0.85*	Pakistan (337)	0.42*
Columbia (545)	0.54*	Peru (442)	0.30*
Costa Rica (546)	0.65*	Philippines (558)	0.79*
Denmark (581)	0.58*	Poland (545)	0.62*
Dominican Republic (507)	0.65*	Portugal (516)	0.71*
Egypt (359)	0.67*	Saudi Arabia (211)	0.85*
El Salvador (314)	0.45*	Singapore (550)	0.82*
Finland (536)	0.72*	South Africa (568)	0.82*
France (568)	0.70*	Spain (581)	0.78*
Germany (581)	0.67*	Sri Lanka (295)	0.54
Guatemala (369)	0.50	Sweden (581)	0.69*
Honduras (284)	0.60*	Switzerland (577)	0.79*
Hong Kong (365)	0.78*	Thailand (581)	0.83*
Hungary (473)	0.61*	Trinidad (342)	0.55*
India (565)	0.80*	Turkey (553)	0.57*
Indonesia (565)	0.67*	United Kingdom (581)	0.68*
Ireland (560)	0.76*	Venezuela (477)	0.47
Israel (561)	0.75*	Vietnam (532)	0.66*
Italy (568)	0.84*		

*Significant at the 5% level

 † Number of sector pairs

Table 19: Sign Tests, Sector by Sector, 2006

Sector(N^\dagger)	Test	Sector(N^\dagger)	Test
Animal foods (686)	0.70*	Lime & gypsum (74)	0.61*
Grain & oilseed (418)	0.64*	Other nonmetallic (346)	0.65*
Sugar & confectionary (2014)	0.64*	Iron & steel (398)	0.69*
Fruit & veg preserves (1535)	0.68*	Steel products (583)	0.61*
Dairy (1284)	0.71*	Aluminium (484)	0.56*
Meat products (623)	0.79*	Other nonferrous (571)	0.66*
Seafood (2112)	0.80*	Foundries (204)	0.54
Bakeries & tortillas (3097)	0.67*	Closures & seals (221)	0.52
Foods, nesoi (980)	0.58*	Cutlery & handtools (587)	0.67*
Beverages (1049)	0.74*	Structural metals (746)	0.60*
Tobacco products (373)	0.43*	Boilers & containers (768)	0.62*
Fibers, yarns & threads (177)	0.67*	Hardware (441)	0.68*
Fabrics (302)	0.64*	Springs & wire (596)	0.69*
Finished fabrics (878)	0.64*	Bolts, nuts, etc. (222)	0.68*
Textile furnishings (409)	0.58*	Other fabr metal (559)	0.69*
Other textiles (469)	0.63*	Ag & cnstrct machinery (940)	0.74*
Apparel (558)	0.67*	Industrial machinery (489)	0.62*
Apparel accessories (898)	0.67*	Engines & turbines (1356)	0.68*
Leather tanning (291)	0.79*	Other machinery (575)	0.72*
Footwear (355)	0.65*	Computer equip (678)	0.77*
Other leather (167)	0.71*	Comm equip (505)	0.72*
Sawmill & wood (373)	0.77*	Audio & video (573)	0.70*
Engineered wood (541)	0.62*	Semiconductors, etc. (2484)	0.75*
Other wood (666)	0.65*	Mag & optical media (331)	0.53
Pulp & paper (1010)	0.54*	Lighting equipment (151)	0.61*
Converted paper (373)	0.66*	Appliances (486)	0.65*
Petroleum & coal (42)	0.86*	Electrical equip (1569)	0.78*
Basic chemicals (1570)	0.73*	Electrical, nesoi (675)	0.74*
Syn rubber & fibers (1432)	0.68*	Motor vhcle bodies (231)	0.71*
Fertilizers, etc. (404)	0.64*	Motor vehicle parts (766)	0.78*
Pharmaceuticals (278)	0.67*	Aerospace (3025)	0.46
Paints & adhesives (379)	0.63*	Ships & boats (326)	0.49
Other chemical (638)	0.64*	transportation, nesoi (990)	0.56*
Plastics (523)	0.55*	Household furniture (512)	0.69*
Rubber (298)	0.59*	Office furniture (619)	0.67*
Clay & refractory (815)	0.63*	Furniture, nesoi (966)	0.75*
Glass (327)	0.56*	Medical equipment (638)	0.72*

*Significant at the 5% level

 $^\dagger N = (\text{number of sectors each industry either dominates or is dominated by}) \times (\text{number of countries})$

Table 20: Regressions for Chain of Sectors Ranked in the Sense of Definition 1 (Small Sample)

Model :	1	2	3	4	5
N:	2695	2695	2695	2695	2695
Dependent variable is the share of intrafirm imports					
routine	-0.257*** (-7.87)	-0.314*** (-5.45)	-1.276*** (-10.57)	-1.425*** (-7.42)	-1.310*** (-10.38)
ln(K/L)		0.095** (2.02)	0.914*** (8.52)	1.092*** (5.30)	0.942*** (8.50)
ln(S/L)		-0.263*** (-3.93)	-1.023*** (-9.50)	-1.153*** (-6.96)	-1.089*** (-8.75)
ln(R&D)		0.217*** (5.53)	0.416*** (9.17)	0.454*** (7.55)	0.389*** (7.56)
specificity			-1.008*** (-8.44)	-1.080*** (-7.68)	-1.026*** (-8.46)
intermediation				0.124 (1.02)	
dispersion					0.058 (1.02)
fixed effects	country year	country year	country year	country year	country year
R-sq	0.243	0.311	0.364	0.365	0.365

Standardized beta coefficients reported for pooled data from 2000 to 2006.

*, ** and *** indicate significance at the 10, 5 and 1 percent levels.

Standard errors are clustered by country-industry.

T-statistics are in parentheses.

Table 21: Regressions for Chain of Sectors Ranked in the Sense of Definition 1 (Large Sample)

Model :	1	2	3	4	5
N:	3850	3850	3850	3850	3850
Dependent variable is the share of intrafirm imports					
routine	-0.256*** (-9.57)	-0.282*** (-6.00)	-0.406*** (-7.15)	-0.486*** (-8.98)	-0.610*** (-9.63)
ln(K/L)		0.193*** (4.73)	0.252*** (5.76)	0.231*** (5.38)	0.332*** (6.50)
ln(S/L)		-0.267*** (-5.10)	-0.317*** (-6.02)	-0.367*** (-7.01)	-0.600*** (-7.21)
ln(R&D)		0.257*** (6.88)	0.297*** (7.73)	0.327*** (8.52)	0.223*** (4.54)
specificity			-0.166*** (-3.57)	-0.486*** (-7.53)	-0.678*** (-8.26)
intermediation				-0.322*** (-6.25)	-0.484*** (-7.36)
dispersion					0.210*** (3.31)
fixed effects	country year	country year	country year	country year	country year
R-sq	0.211	0.313	0.32	0.342	0.349

Standardized beta coefficients reported for pooled data from 2000 to 2006.

*, ** and *** indicate significance at the 10, 5 and 1 percent levels.

Standard errors are clustered by country-industry.

T-statistics are in parentheses.

Table 22: Regressions for 4-Digit NAICS Manufacturing Sectors

Model :	1	2	3	4	5
N:	29505	29505	29505	29505	29505
Dependent variable is the share of intrafirm imports					
routine	-0.179*** (-17.75)	-0.066*** (-4.78)	-0.067*** (-4.98)	-0.066*** (-4.83)	-0.069*** (-5.07)
ln(K/L)		0.031** (2.43)	0.081*** (4.82)	0.077*** (4.41)	0.055*** (2.99)
ln(S/L)		0.007 (0.46)	-0.013 (-0.87)	-0.014 (-0.91)	-0.015 (-0.97)
ln(R&D)		0.174*** (12.56)	0.139*** (9.51)	0.136*** (9.02)	0.137*** (9.12)
specificity			0.082*** (5.15)	0.082*** (5.15)	0.070*** (4.33)
intermediation				-0.01 (-0.75)	-0.012 (-0.88)
dispersion					0.032** (2.48)
fixed effects	country year	country year	country year	country year	country year
R-sq	0.213	0.235	0.238	0.238	0.24

Standardized beta coefficients reported for pooled data from 2000 to 2006.

*, ** and *** indicate significance at the 10, 5 and 1 percent levels.

Standard errors are clustered by country-industry.

T-statistics are in parentheses.

Table 23: Regressions for Chain of Sectors Ranked in the Sense of Definition 1 (Small Sample) for Restricted Set of Countries

Model :	1	2	3	4	5
N:	1323	1323	1323	1323	1323
Dependent variable is the share of intrafirm imports					
routine	-0.210*** (-4.72)	-0.203*** (-2.77)	-0.988*** (-5.69)	-1.03*** (-4.02)	-0.997*** (-5.60)
ln(K/L)		0.094 (1.49)	0.765*** (5.09)	0.819*** (2.93)	0.773*** (4.98)
ln(S/L)		-0.201** (-2.40)	-0.815*** (-5.38)	-0.854*** (-3.88)	-0.834*** (-4.92)
ln(R&D)		0.261*** (4.86)	0.420*** (6.68)	0.432*** (5.18)	0.412*** (5.92)
specificity			-0.820*** (-5.01)	-0.842*** (-4.40)	-0.825*** (-4.96)
intermediation				0.038 (0.24)	
dispersion					0.017 (0.24)
fixed effects	country year	country year	country year	country year	country year
R-sq	0.229	0.302	0.337	0.337	0.337

Standardized beta coefficients reported for pooled data from 2000 to 2006.

*, ** and *** indicate significance at the 10, 5 and 1 percent levels.

Standard errors are clustered by country-industry.

T-statistics are in parentheses.

Table 24: Correlations between FDI and Exports

correlation between export and FDI dummies	
manufactures	0.28
all services	0.42
most exported services	0.45

Table 25: OLS regression of exports on FDI comparing manufacturing and service industries (t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2	3
Sample:	mfg+svc	svc	mfg
N:	17862	6412	11450
Depvar:	x dummy	x dummy	x dummy
fdi dummy	0.064 (9.06)	0.085 (6.05)	0.031 (4.33)
dispersion	-0.04 (-15.40)	-0.033 (-9.41)	-0.053 (-15.29)
ln(gdp)	0.025 (12.61)	0.056 (14.69)	0.011 (5.08)
ln(distance)	-0.049 (-9.27)	-0.037 (-3.36)	-0.056 (-11.55)
lang distance	0.092 (4.31)	0.058 (0.90)	0.22 (9.68)
literacy	0.115 (6.33)	0.227 (6.48)	0.06 (3.06)
rel wages	-0.004 (-2.99)	-0.004 (-1.52)	-0.004 (-2.51)
nonroutine	0.122 (17.09)	0.164 (9.50)	-0.034 (-3.53)
R-sq	0.233	0.295	0.061

Table 26: No independent relationship exists between OECD 1993 FDI restrictions and exports (t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2	3	4
N:	602	756	602	756
Depvar:	ln(x)	x dummy	ln(x)	x dummy
oecd93	0.160 (0.65)	-0.012 (-0.37)	-0.302 (-1.18)	0.022 (0.71)
dispersion	-0.531 (-6.80)	-0.118 (-10.83)		
ln(gdp)	0.871 (8.95)	0.062 (4.83)		
ln(distance)	-0.583 (-3.63)	-0.028 (-1.28)		
lang distance	-1.557 (-0.93)	0.061 (0.24)		
literacy	6.717 (1.58)	0.267 (0.48)		
rel wages	0.417 (1.28)	0.065 (1.46)		
Fixed Effects	year	year	year country industry	year country industry
R-sq	0.243	0.172	0.570	0.628

Table 27: First stage coefficients on OECD 1993 FDI restrictions (t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2	3	4
N:	602	756	602	756
Depvar:	ln(HFDI)	HFDI Dummy	ln(all FDI)	all FDI Dummy
oecd93	-0.594 (-2.54)	-0.094 (-3.02)	-0.505 (-2.27)	-0.094 (-3.02)
dispersion	0.65 (8.14)	0.053 (4.15)	0.784 (9.37)	0.044 (3.44)
ln(gdp)	1.024 (10.61)	0.073 (4.77)	1.049 (9.64)	0.078 (5.15)
ln(distance)	-0.354 (-3.22)	-0.014 (-0.60)	-0.362 (-2.99)	-0.008 (-0.35)
lang distance	-4.506 (-5.67)	-0.38 (-2.79)	-4.779 (-5.59)	-0.388 (-2.85)
literacy	0.723 (0.25)	0.858 (1.89)	0.931 (0.31)	0.928 (2.05)
rel wages	-0.254 (-0.53)	-0.044 (-0.55)	-0.282 (-0.54)	-0.056 (-0.71)
nonroutine	0.105 (1.05)	0.063 (3.42)	0.155 (1.51)	0.058 (3.17)
R-sq	0.344	0.178	0.331	0.178

Table 28: Second stage results for export volumes, instrumenting for FDI using OECD 1993 FDI restrictions (t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2	3	4
N:	602	602	602	602
Depvar:	ln x	ln x	ln x	ln x
ln H fdi (IV: oecd93)	0.792 (5.28)			
H fdi dummy (IV: oecd93)		5.516 (5.16)		
ln all fdi (IV: oecd93)			0.75 (5.21)	
all fdi dummy (IV: oecd93)				5.808 (5.07)
dispersion	-0.103 (-1.26)	-0.112 (-1.37)	-0.09 (-1.09)	-0.113 (-1.38)
ln(gdp)	0.759 (8.15)	0.736 (7.81)	0.793 (8.60)	0.735 (7.79)
ln(distance)	-0.617 (-3.77)	-0.631 (-3.86)	-0.599 (-3.62)	-0.632 (-3.87)
lang distance	-1.229 (-0.78)	-1.151 (-0.73)	-1.34 (-0.85)	-1.145 (-0.73)
literacy	8.167 (1.91)	8.597 (2.01)	7.582 (1.77)	8.63 (2.02)
relative wage	0.417 (1.27)	0.43 (1.31)	0.401 (1.21)	0.431 (1.31)
nonroutine	0.702 (1.97)	0.684 (1.94)	0.725 (2.01)	0.682 (1.93)
R-sq	0.238	0.235	0.238	0.234

Table 29: Second stage results for export dummies, instrumenting for FDI using OECD 1993 FDI restrictions (t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2	3	4
N:	756	756	756	756
Depvar:	x dum	x dum	x dum	x dum
ln H fdi (IV: oecd93)	0.117 (5.58)			
H fdi dummy (IV: oecd93)		0.857 (5.60)		
ln all fdi (IV: oecd93)			0.103 (5.28)	
all fdi dummy (IV: oecd93)				0.916 (5.61)
dispersion	-0.015 (-1.60)	-0.014 (-1.44)	-0.017 (-1.80)	-0.013 (-1.42)
ln(gdp)	0.048 (3.69)	0.043 (3.31)	0.054 (4.20)	0.043 (3.27)
ln(distance)	-0.034 (-1.50)	-0.037 (-1.62)	-0.031 (-1.34)	-0.037 (-1.63)
lang distance	0.093 (0.36)	0.107 (0.42)	0.075 (0.29)	0.109 (0.42)
literacy	0.432 (0.74)	0.499 (0.85)	0.347 (0.59)	0.505 (0.86)
relative wage	0.069 (1.48)	0.072 (1.54)	0.066 (1.41)	0.072 (1.55)
nonroutine	0.11 (1.89)	0.106 (1.84)	0.115 (1.94)	0.106 (1.84)
R-sq	0.09	0.092	0.084	0.092

Table 30: Second stage results for export volumes, instrumenting for FDI using OECD 1993 FDI restrictions, fixed effects (t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2	3	4
N:	602	602	602	602
Depvar:	ln x	ln x	ln x	ln x
ln H fdi (IV: oecd93)	1.075 (10.00)			
H fdi dummy (IV: oecd93)		7.949 (9.29)		
ln all fdi (IV: oecd93)			0.857 (9.84)	
all fdi dummy (IV: oecd93)				8.19 (8.96)
Fixed effects	country industry year	country industry year	country industry year	country industry year
R-sq	0.635	0.627	0.633	0.624

Table 31: Second stage results for export dummies, instrumenting for FDI using OECD 1993 FDI restrictions, fixed effects (t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2	3	4
N:	756	756	756	756
Depvar:	x dum	x dum	x dum	x dum
ln H fdi (IV: oecd93)	0.094 (7.07)			
H fdi dummy (IV: oecd93)		0.744 (7.15)		
ln all fdi (IV: oecd93)			0.075 (6.99)	
all fdi dummy (IV: oecd93)				0.78 (7.02)
Fixed effects	country industry year	country industry year	country industry year	country industry year
R-sq	0.645	0.645	0.645	0.645

Table 32: No independent relationship exists between BITS and exports (t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2
N:	454	458
Depvar:	ln x	x dummy
bits1	-0.218 (-1.47)	-0.024 (-1.26)
ln(gdp)	0.777 (16.73)	0.000 (0.27)
ln(distance)	-0.769 (-6.89)	-0.008 (-1.64)
lang distance	0.784 (1.92)	0.025 (1.31)
literacy	1.427 (5.15)	-0.026 (-1.92)
rel wages	-0.005 (-0.19)	0.001 (0.78)
Fixed Effects	year	year
R-sq	0.818	0.025

Table 33: First stage coefficients on BITS (t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2	3	4
N:	402	458	402	458
Depvar:	ln(HFDI)	HFDI Dummy	ln(all FDI)	all FDI Dummy
bits1	0.376 (1.74)	0.123 (3.66)	0.411 (1.71)	0.122 (3.65)
ln(gdp)	1.046 (19.46)	0.046 (5.84)	1.024 (17.09)	0.045 (5.70)
ln(distance)	-0.367 (-2.19)	-0.037 (-1.38)	-0.426 (-2.27)	-0.035 (-1.30)
lang distance	-1.523 (-2.28)	-0.07 (-0.65)	-1.489 (-1.99)	-0.051 (-0.48)
literacy	3.496 (6.55)	0.457 (6.05)	4.186 (7.02)	0.469 (6.27)
rel wages	-0.004 (-0.09)	-0.009 (-1.62)	-0.002 (-0.03)	-0.01 (-1.82)
Fixed Effects	year	year	year	year
R-sq	0.71	0.409	0.671	0.413

Table 34: Second stage results for export volumes, instrumenting for horizontal FDI using BITS (t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2	3	4	5	6
Sample:	mfg+svc	svc	mfg	mfg+svc	svc	mfg
N:	454	229	225	454	229	225
Depvar:	ln x	ln x	ln x	ln x	ln x	ln x
ln H fdi (IV: bits)	0.596 (3.78)	0.848 (4.68)	0.337 (1.33)			
H fdi dummy (IV: bits)				0.929 (1.20)	2.63 (3.86)	-0.818 (-0.61)
ln(gdp)	0.146 (0.77)	-0.162 (-0.70)	0.461 (1.57)	0.741 (11.91)	0.627 (8.73)	0.859 (8.68)
ln(distance)	-0.546 (-3.98)	-0.047 (-0.31)	-1.046 (-4.93)	-0.722 (-5.88)	-0.246 (-1.95)	-1.202 (-6.30)
lang distance	1.68 (3.63)	0.703 (1.42)	2.64 (3.30)	0.918 (2.24)	-0.237 (-0.53)	2.08 (2.99)
literacy	-0.644 (-1.16)	-1.93 (-3.19)	0.673 (0.75)	1.069 (2.64)	-0.063 (-0.14)	2.221 (3.52)
rel wages	-0.003 (-0.13)	0.026 (0.85)	-0.033 (-0.93)	0.008 (0.31)	0.057 (1.78)	-0.041 (-1.13)
Fixed Effects	year	year	year	year	year	year
R-sq	0.824	0.829	0.718	0.818	0.816	0.717

Table 35: econd stage results for export volumes, instrumenting for total FDI using BITS
(t-statistics in parenthesis, standard errors clustered by country-industry)

Model :	1	2	3	4	5	6
Sample:	mfg+svc	svc	mfg	mfg+svc	svc	mfg
N:	454	229	225	454	229	225
Depvar:	ln x	ln x	ln x	ln x	ln x	ln x
ln all fdi (IV: bits)	0.477 (3.74)	0.696 (4.79)	0.251 (1.22)			
all fdi dummy (IV: bits)				0.927 (1.15)	2.706 (3.84)	-0.902 (-0.65)
ln(gdp)	0.282 (1.82)	0.012 (0.06)	0.558 (2.32)	0.747 (8.63)	0.628 (8.76)	0.743 (11.93)
ln(distance)	-0.56 (-4.14)	-0.06 (-0.41)	-1.062 (-5.06)	-0.737 (-3.38)	-0.249 (-1.98)	-0.725 (-5.92)
lang distance	1.488 (3.38)	0.456 (0.98)	2.505 (3.28)	0.94 (1.27)	-0.282 (-0.63)	0.901 (2.19)
literacy	-0.551 (-1.02)	-1.876 (-3.22)	0.804 (0.92)	1.051 (1.50)	-0.13 (-0.29)	1.058 (2.51)
rel wages	-0.004 (-0.17)	0.025 (0.80)	-0.034 (-0.94)	0.01 (0.25)	0.06 (1.89)	0.009 (0.34)
Fixed Effects	year	year	year	year	year	year
R-sq	0.823	0.83	0.718	0.818	0.816	0.717

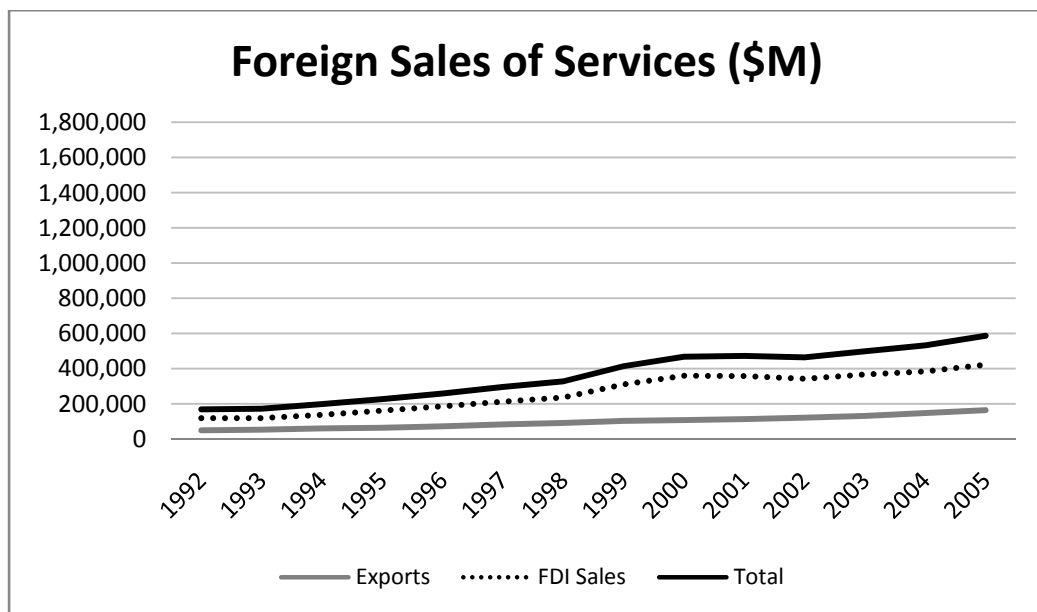
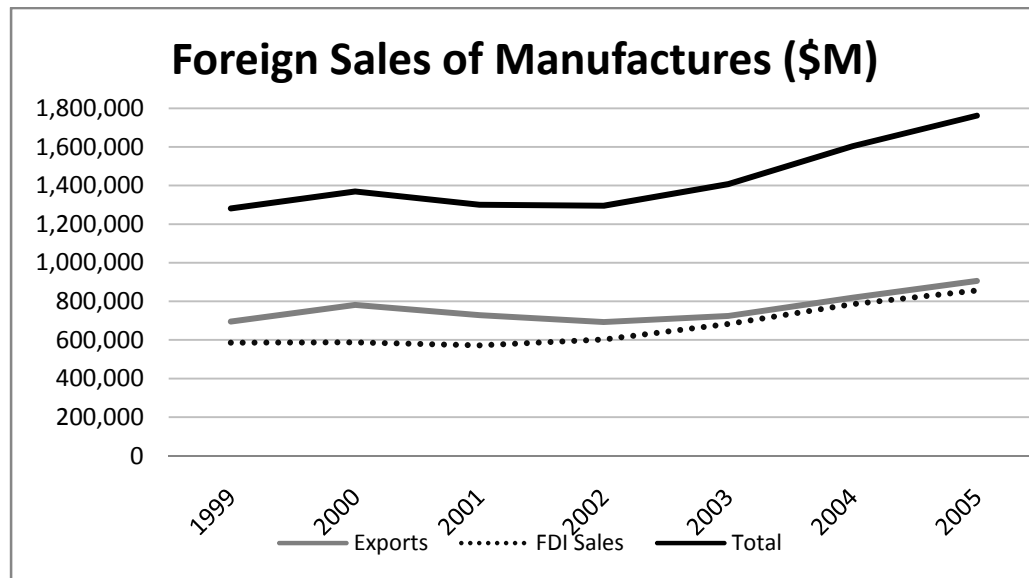


Figure 1: Share of export and FDI sales in manufacturing and service industries

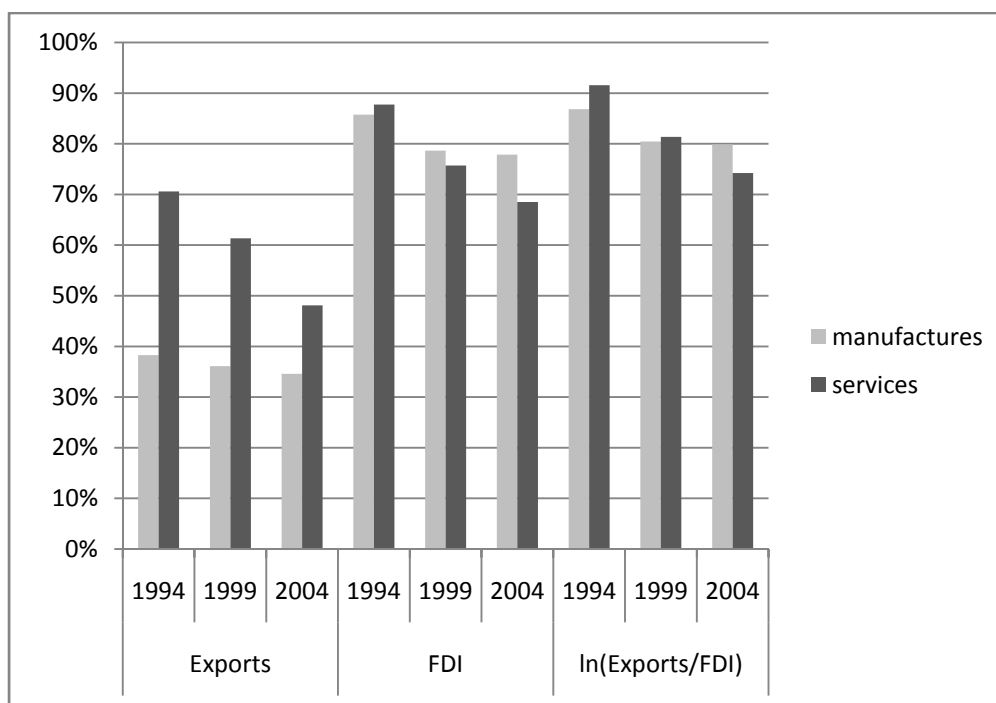


Figure 2: Share of zeros in all possible country-industry pairs

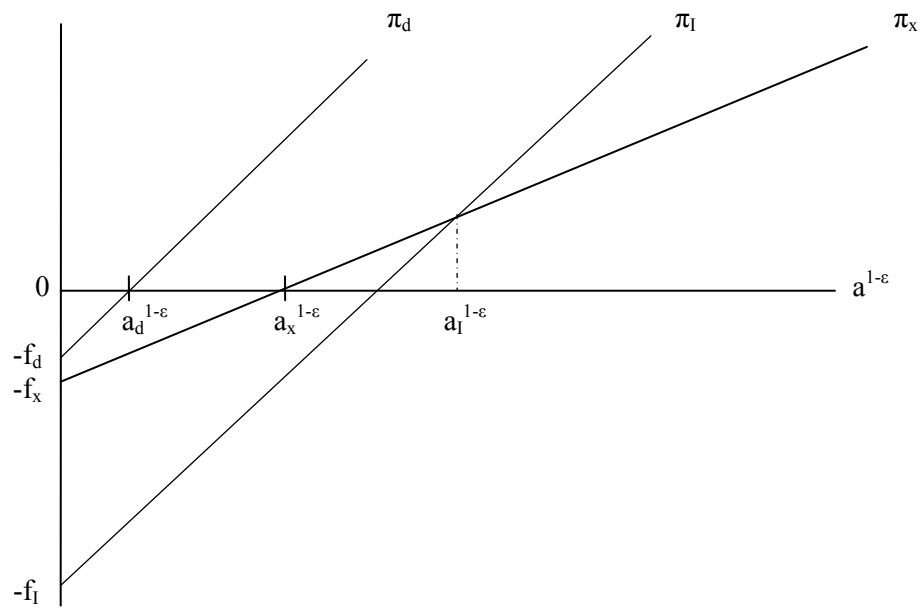


Figure 3: Profits from Domestic Sales, Exports and FDI in the Helpman, Melitz and Yeaple Model

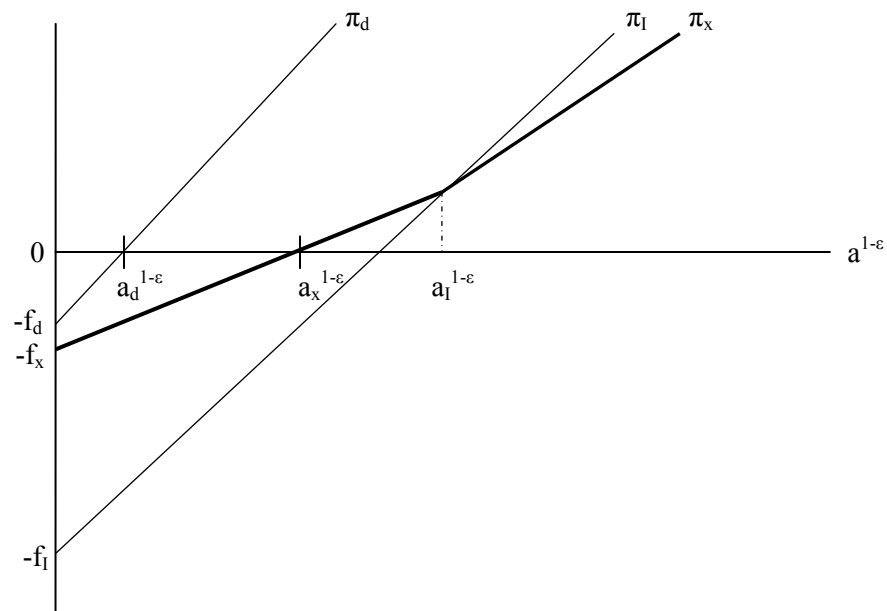


Figure 4: Profits from Domestic Sales, Exports and FDI when Exports and FDI are Complements