ADAPTATION AND THE BOUNDARY OF MULTINATIONAL FIRMS

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Abstract—This paper offers the first empirical analysis of the impact of adaptation on the boundary of multinational firms. To do so, we develop a ranking of sectors in terms of "routineness" by merging two sets of data: ratings of occupations by their intensities in solving problems from the U.S. Department of Labor's Occupational Information Network and U.S. employment shares of occupations by sectors from the Bureau of Labor Statistics Occupational Employment Statistics. Using U.S. Census trade data, we demonstrate that the share of intrafirm trade tends to be higher in less routine sectors.

I.   Introduction

MANY aspects of contractual incompleteness have been analyzed in the international trade literature as explanations for why multinationals should prefer internal versus external procurement, but just two strands of theory have dominated empirical application.[1] The older strand (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 (Antràs, 2003; Antràs & Helpman, 2004, 2008) emphasizes the hold-up 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 should be held by the party whose incentive to invest is relatively more important; hence, supply should be kept within the multinational firm when its headquarters makes the larger contribution to the relationship.[2]

In this paper, we emphasize a different source of contractual frictions that arises ex post due to the nonroutine quality of the 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. The central idea of our paper is that adaptation is more efficiently carried out within a firm 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 synthesizing work of Tadelis (2002) and Gibbons (2005).[3] In section II, 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 "routineness" is an important determinant of the boundary of multinational firms, we need data on multinational activities. Following Antràs (2003), Yeaple (2006), Nunn and Trefler (2008), and Bernard et al. (2008), we use sector-level data on the intrafirm imports of U.S. multinationals.[4] 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. Not surprisingly, 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 "solving problems."[5] 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 "solving problems" is interpreted as a measure of the need for ex post adaptation, the opposite of which we refer to as "task routineness." The main prediction of our simple trade model is that if vertical integration increases productivity ex post but reduces it ex ante, then the share of the value of imports that is intrafirm should be higher in less routine sectors.

For our first empirical exercise, we consider simple sign tests for all pairs of sectors ranked in terms of average task routineness, where the average is computed using task employment shares. Sign tests offer mild but encouraging support for our prediction: in 57% of all cases, the less routine sector has a higher share of intrafirm imports. Note that these tests do not control for any other determinant of the boundary of multinational firms.

In order to control for these other determinants, we turn to cross-sector regressions with country-year fixed effects. We

[1] See Helpman (2006) and Antràs and Rossi-Hansberg (2008) for recent surveys of this literature.

[2] Recent 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 Carr et al. (2001) and Yeaple (2003).

[3] For an application of the adaptation approach to vertical integration in the U.S. airline industry, see Forbes and Lederman (2009).

[4] Throughout our empirical analysis, "intrafirm imports of U.S. multinationals" will include both imports from foreign affiliates of U.S. parents and imports from foreign parents of U.S. affiliates.

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

find that average task routineness is a stronger predictor of the intrafirm share of imports than any of the other variables shown by previous studies to influence the U.S. intrafirm import share besides R&D intensity. According to our most conservative estimate, a 1-standard-deviation decrease in the average task routineness of a sector leads to a 0.08 standard deviation increase in the share of intrafirm imports, or an additional 2% of import value that is intrafirm.

As robustness checks, we also rerun these regressions splitting our country sample into high-income OECD countries and all other countries, restricting our sample of countries to those for which at least two-thirds of intrafirm U.S. imports are imported by U.S.-owned firms, or using only observations with a strictly positive share of intrafirm imports. In all cases, we obtain qualitatively similar results: less routine sectors have higher shares 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, we develop a simple theoretical model of imports by U.S. multinationals. Section III describes our data sources and provides some descriptive statistics. We present our empirical results in section IV and robustness checks of these results in section V. Our conclusions are in section VI.

II. Theoretical Framework

A. Basic Environment

We consider a world economy with $c = 1, \ldots, C$ countries; $s = 1, \ldots, S$ goods or sectors; $t = 1, \ldots, T$ tasks; and one factor of production, labor, immobile across countries. We denote by w_c the wage per efficiency unit of labor in country c. There are two types of firms: intermediate suppliers and final good producers.

Intermediate suppliers. 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

$$Y_c^s(t) = \frac{L_c^s(t)}{a_c(t, X)}, \tag{1}$$

where $L_c^s(t) \geq 0$ is the amount of labor allocated to task t in sector s and country c; $a_c(t, X) > 0$ is the amount of labor necessary to perform task t once in country c; and X is a binary variable related to the choice of firm organization as described below.

Final goods producers. Final goods producers are present only in country 1, the United States. They transform tasks into goods using a constant returns to scale technology. The total amount of good s produced with tasks from country c is given by

$$Y_c^s = F^s\big[Y_c^s(1), \ldots, Y_c^s(T)\big]. \tag{2}$$

We denote by $p_c(t)$ the price of task t in country c and by $b_c^s(t) \equiv p_c(t)Y_c^s(t)/\sum_{t'=1}^T p_c(t')Y_c^s(t')$ the intensity of task t in sector s and country c. For any pair of tasks, t_1 and t_2, and any pair of sectors, s_1 and s_2, we say that s_1 is relatively more intensive in task t_1 in country c if $b_c^{s_1}(t_1)/b_c^{s_1}(t_2) \geq b_c^{s_2}(t_1)/b_c^{s_2}(t_2)$. In line with traditional trade models, we rule out task intensity reversals. If there exists a country c such that $b_c^{s_1}(t_1)/b_c^{s_1}(t_2) \geq b_c^{s_2}(t_1)/b_c^{s_2}(t_2)$, then we assume that $b_{c'}^{s_1}(t_1)/b_{c'}^{s_1}(t_2) \geq b_{c'}^{s_2}(t_1)/b_{c'}^{s_2}(t_2)$ for all countries $c' = 1, \ldots, C$.

Market structure. 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.

B. Adaptation and the Make-or-Buy Decision

For each task, there exist two states of the world: routine and problematic. Tasks differ only in their probabilities $\mu(t)$ of being in the routine state. $\mu(t) \geq 0$ is an exogenous characteristic of a task, which we refer to 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 goods producers in the United States can choose between two organizations, $X \in \{I, O\}$. Under organization I (integration), U.S. final goods 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

$$a_c(t, X) = \alpha_c(X) + [1 - \mu(t)]\beta_c(X), \tag{3}$$

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:

> H_0. In any country $c = 1, \ldots, C$, 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. Although H_0 admittedly is in reduced form, there are many theoretical reasons, as we briefly mentioned in the introduction, as to why it may hold in practice:

- Opportunism. It is standard to claim that external suppliers have stronger incentives to exert effort than internal suppliers (Alchian & 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).[6]
- 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 & Tadelis, 2001). Exercise of command and control within the firm avoids renegotiation costs.
- Communication. Crémer, Garicano, and Prat (2007) argue that agents within the boundary of a firm develop a common "code" or "language" to facilitate communication.[7] 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 that headquarters and the supplier share will reduce the cost of the communication necessary to resolve them.

C. Testable Implications

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

$$X_c^*(t) = \underset{X \in \{I, O\}}{\mathrm{argmin}} \; a_c(t, X). \tag{4}$$

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

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

Proof. Let $\Delta_c(t) \equiv a_c(t, O) - a_c(t, I)$. By equation (3), 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 $t_0 \in \{1, \ldots, T\}$, then equation (4) 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 have access only 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 1. *A sector s is less routine than another sector s' in country c if, for every pair of tasks $T \geq t \geq t' \geq 1$, task intensities satisfy $b_c^s(t)/b_c^s(t') \geq b_c^{s'}(t)/b_c^{s'}(t')$.*

According to definition 1, a sector s is less routine than another sector s' in country c if s is relatively more intensive in the less routine tasks.[8] Given our assumption of no task intensity reversals, if a sector s is less routine than another sector s' in a given country c, then s is less routine than s' in all countries. From now on and without any risk of confusion, we simply say that "s is less routine than s'."

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

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

Proof. By lemma 1, we know that

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

Using our definition of $b_c^s(t)$, we can rearrange the previous expression as

$$\chi_c^s = \sum_{t=t_c^*+1}^{T} b_c^s(t). \tag{5}$$

Now consider two sectors, s and s', such that s is less routine than s'. It is easy to check that definition 1 implies

$$\sum_{t=t_c^*+1}^{T} b_c^s(t) \geq \sum_{t=t_c^*+1}^{T} b_c^{s'}(t). \tag{6}$$

Equation (5) and inequality (6) imply that for any country $c = 1, \ldots, C$, 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 IIIA, 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 model to the data, we will make the implicit assumption that the probability that a

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[6] Tadelis in turn cites Williamson (1985, p. 140), who wrote that "low powered incentives have well known adaptability advantages."

[7] Their 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.

[8] Formally, s is less routine than another sector s' if the distribution of task intensities in s dominates the distribution of task intensities in s' in terms of the likelihood ratio. Costinot (2009) and Costinot and Vogel (2009) offer further details about the link between factor intensity and monotone likelihood ratio dominance.

TABLE 1.—RANKING OF SECTORS BY SHARE OF INTRAFIRM IMPORTS IN 2006

	Sector	Share		Sector	Share
1	Motor vehicles	0.92	40	Bakeries & tortillas	0.35
2	Pharmaceuticals	0.80	41	Bolts, nuts, screws, etc.	0.35
3	Magnetic & optical media	0.71	42	Glass & glass products	0.35
4	Semiconductors, etc.	0.69	43	Fruit & vegetable preserves	0.34
5	Transportation equipments nesoi	0.68	44	Boilers & containers	0.33
6	Computer equipment	0.67	45	Converted paper	0.33
7	Audio & video equipment	0.64	46	Aerospace	0.32
8	Medical equipment & supplies	0.64	47	Cement and concrete	0.32
9	Rubber products	0.64	48	Cutlery & handtools	0.32
10	Electrical equipment	0.63	49	Purchased steel products	0.32
11	Syn rubber & fibers	0.63	50	Office furniture	0.29
12	Engines & turbines	0.61	51	Beverages	0.28
13	Communications equipment	0.60	52	Crowns, closures & seals	0.28
14	Pesticides, fertilizers, etc.	0.60	53	Electric lighting equipment	0.28
15	Petroleum & coal	0.60	54	Springs & wire	0.28
16	Agricultural & construction machinery	0.59	55	Foundries	0.27
17	Other chemical products	0.59	56	Grain & oilseed milling	0.27
18	Paints & adhesives	0.59	57	Plastics	0.27
19	Motor vehicle parts	0.57	58	Clay & refractory	0.26
20	Basic chemicals	0.56	59	Lime & gypsum	0.26
21	Aluminium	0.55	60	Architectural & structural metals	0.24
22	Electrical components, nesoi	0.50	61	Nonferrous (excluding aluminum)	0.24
23	Railroad rolling stock	0.49	62	Furniture, nesoi	0.23
24	Motor vehicle bodies	0.48	63	Other wood	0.23
25	Other machinery	0.46	64	Engineered wood	0.22
26	Sugar & confectionary	0.45	65	Fabrics	0.20
27	Pulp, paper, & paperboard	0.43	66	Other nonmetallic mineral	0.20
28	Industrial machinery	0.42	67	Other textiles	0.19
29	Hardware	0.40	68	Meat products	0.18
30	Household appliances	0.40	69	Sawmill & wood	0.18
31	Other fabricated metal	0.40	70	Seafood	0.17
32	Animal foods	0.39	71	Apparel	0.14
33	Iron & steel	0.39	72	Apparel accessories	0.13
34	Dairy	0.38	73	Other leather	0.13
35	Tobacco products	0.38	74	Household furniture	0.12
36	Finished fabrics	0.37	75	Fibers, yarns, & threads	0.11
37	Foods, nesoi	0.36	76	Textile furnishings	0.10
38	Leather tanning	0.36	77	Footwear	0.04
39	Ships & boats	0.36			

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, it should be clear that the assumption that the ranking of sectors in terms of routineness does not vary across countries is convenient but strong. Empirically this assumption allows us to make inferences about the task composition of U.S. imports from U.S. (rather than foreign) data on employment across tasks. However, it de facto rules out technological differences across countries due to the fragmentation of the production process.[9] We come back to this important issue in sections IV and V.

Finally, we point out that the fact that in a given country 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.[10]

[9] See Feenstra and Hanson (1996) and Grossman and Rossi-Hansberg (2008) for trade models developed along those lines.
[10] This directly derives from the fact that if a distribution F dominates another distribution G in terms of the likelihood ratio, then the expected value of any increasing function is higher under F than under G.

III. Data

To investigate empirically whether adaptation is an important determinant of the boundary of multinationals, we need measures of the share of intrafirm trade at the sector and country level and routineness at the sector level.

A. Measuring Intrafirm Trade at the Sector and Country Levels

All of our trade data are from the U.S. Census Bureau Related Party Trade database and cover the years 2000 through 2006.[11] Variables reported in this database are the total value of all U.S. imports and the value of related-party,

[11] The 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 in the United States. 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 data set 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 five years and smaller annual surveys in nonbenchmark years, with the firm size cutoff for inclusion in these surveys changing over time. However, for robustness, we have also tested our model using the BEA data and obtained similar results.

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 United States and asks for the value of the shipment and whether the transaction is with a related party. These data are collected at the ten-digit HS level and reported at the two- through six-digit level for both HS and NAICS codes. We use the four-digit NAICS data for our analysis to facilitate comparison with other studies in the cross-sector regressions below. Table 1 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 United States, comprising 99% of all U.S. imports. This results in a set of 55 exporters in 77 sectors over seven years.

B. Measuring Routineness at the Sector Level

In order to measure routineness at the sector level, we combine task-level data from the Standard Occupational Classification (SOC) system with sector-level data from the Bureau of Labor Statistics Occupational Employment Statistics 2006, following Oldenski (2009).

We define a task t as a six-digit occupation in the SOC system. To measure how routine each of these tasks is, we use the June 2007 version of O*NET. This database includes measures of the importance, on a scale from 0 to 100, of more than 200 worker and occupational characteristics in about 800 tasks. Such characteristics include finger dexterity, oral 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

$$\mu(t) = 1 - P(t)/100, \tag{7}$$

where $P(t) \in [0, 100]$ is equal to the importance of making decisions and solving problems of a six-digit occupation, t, according to O*NET. Table 2 presents the ten most and ten least routine tasks in our sample.

We define a sector as a four-digit industry in the North American Industry Classification System (NAICS). Equation (1) and perfect competition imply

$$b_c^s(t) = \frac{w_c L_c^s(t)}{\sum_{t=1}^{T} w_c L_c^s(t)} = \frac{L_c^s(t)}{\sum_{t=1}^{T} L_c^s(t)}. \tag{8}$$

In order to rank sectors in terms of routineness, we should, in principle, compute measures of task intensity, $b_c^s(t)$, for all countries $c = 1, \ldots, C$. Since there is no task intensity reversal, however, we can simply focus on one of these countries. In this paper, we use U.S. data from the Bureau of

TABLE 2.—RANKING OF TEN MOST AND TEN LEAST ROUTINE TASKS

Top 10 tasks, from most to least routine	
1	Graders and sorters, agricultural products
2	Electromechanical technicians
3	Maids and housekeeping cleaners
4	Shoe and leather workers and repairers
5	Structural metal fabricators and fitters
6	Meat, poultry, and fish cutters and trimmers
7	File clerks
8	Textile knitting and weaving machine setters, operators, and tenders
9	Food and tobacco roasting, baking, and drying machine operators and tenders
10	Cutters and trimmers, hand
Bottom 10 tasks, from least to most routine	
1	Computer software engineers, systems software
2	Chief executives
3	Aerospace engineers
4	Computer operators
5	Operations research analysts
6	Transportation, storage, and distribution managers
7	Computer hardware engineers
8	Human resources managers
9	Biomedical engineers
10	Civil engineers

Labor Statistics (BLS) Occupational Employment Statistics 2006 on the share of employment of six-digit occupations[12] to compute our measure of task intensity, $b_1^s(t)$, in all sectors $s = 1, \ldots, S$.[13] We also use U.S. data for the sector-level controls listed in section IIIC, where we have simply followed the practice of the studies from which those controls were taken.

Ideally, armed with measures of $\mu(t)$ and $b_1^s(t)$, we would then like to rank sectors in terms of routineness by checking, for any pair of sectors, whether the inequality introduced in definition 1 is satisfied. While this approach has clear theoretical foundations, it faces one important problem in practice: very few sectors can be ranked in this fashion in our sample. We therefore follow a more reduced-form approach in our empirical analysis that allows us to consider the full sample of NAICS four-digit sectors. For any sector $s = 1, \ldots, S$, we compute the average task routineness,

$$\mu^s = \sum_{t=1}^{T} b_1^s(t)\mu(t).$$

We then use μ^s as our proxy for routineness at the sector level, formally assuming that a sector s is less routine than a sector s' if and only if $\mu^s \leq \mu^{s'}$. It should be clear that this definition is weaker than the one introduced in definition 1. If s is less routine than s' in the sense of definition 1, then the average routineness of tasks in sector s must be lower than

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[12] Strictly speaking, use of employment holds constant the number of efficiency units per worker across occupations.

[13] The BLS and O*NET data sets both use six-digit Standard Occupational Classification (SOC) codes, so using these two data sources allows us to match routineness and employment data for about 800 occupations without any concordance problems. We are not aware of any other publicly available sources that provide this level of detail.

TABLE 3.—RANKING OF SECTORS FROM LOWEST TO HIGHEST AVERAGE TASK ROUTINENESS

	Sector	μ^s		Sector	μ^s
1	Computer equipment	0.308	40	Bolts, nuts, screws, etc.	0.477
2	Basic chemicals	0.336	41	Aluminium	0.477
3	Pharmaceuticals	0.340	42	Nonferrous (excluding aluminum)	0.480
4	Pulp, paper, & paperboard	0.343	43	Household appliances	0.481
5	Other chemical products	0.357	44	Agricultural and construction machinery	0.481
6	Communications equip	0.357	45	Transport equipment, nesoi	0.485
7	Converted paper	0.363	46	Other fabricated metal	0.486
8	Pesticides, etc.	0.364	47	Lime & gypsum	0.486
9	Paints & adhesives	0.367	48	Tobacco products	0.490
10	Crowns, closures, & seals	0.374	49	Ships & boats	0.491
11	Magnetic & optical media	0.375	50	Dairy	0.491
12	Aerospace	0.376	51	Grain & oilseed milling	0.491
13	Audio & video equipment	0.379	52	Boilers & containers	0.492
14	Syn rubber & fibers	0.388	53	Foods, nesoi	0.495
15	Engines & turbines	0.391	54	Purchased steel products	0.496
16	Cutlery & handtools	0.394	55	Plastics	0.501
17	Petroleum & coal	0.398	56	Fruit & vegetable preserves	0.503
18	Medical equipment & supplies	0.401	57	Other nonmetallic mineral	0.506
19	Hardware	0.404	58	Architectural & structural metals	0.506
20	Electrical components, nesoi	0.406	59	Fabrics	0.509
21	Foundries	0.408	60	Other textiles	0.509
22	Clay & refractory	0.410	61	Springs & wire	0.509
23	Electrical equipment	0.411	62	Motor vehicles	0.510
24	Cement and concrete	0.411	63	Textile furnishings	0.513
25	Electric lighting equipment	0.418	64	Sugar & confectionary	0.514
26	Semiconductors, etc.	0.433	65	Finished fabrics	0.515
27	Sawmill & wood	0.437	66	Fibers, yarns, & threads	0.517
28	Office furniture	0.438	67	Railroad rolling stock	0.519
29	Engineered wood	0.438	68	Apparel	0.521
30	Industrial machinery	0.440	69	Bakeries & tortillas	0.523
31	Other wood	0.444	70	Apparel accessories	0.524
32	Motor vehicle bodies	0.450	71	Glass & glass products	0.525
33	Household furniture	0.452	72	Animal foods	0.529
34	Furniture, nesoi	0.454	73	Other leather	0.538
35	Other machinery	0.458	74	Leather tanning	0.545
36	Rubber products	0.459	75	Footwear	0.562
37	Iron & steel	0.469	76	Seafood	0.609
38	Beverages	0.470	77	Meat products	0.673
39	Motor vehicle parts	0.471			

the average routineness of tasks in s', but the converse is not true.[14]

Table 3 lists the 77 sectors in our sample ranked by their average task routineness.

C.   Sector-Level Controls

We use U.S. sector-level 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 Antràs (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 construct a measure of productivity dispersion. This measure is the coefficient of variation of sales by firms within an industry computed using the Compustat database. Finally, we follow Bernard et al. (2008) and use the weighted average of retail and wholesale employment shares of importing firms in an industry as a control for intermediation. NBER variables, which are collected at the four-digit SIC level, are converted to four-digit NAICS using concordance tables created using information from the Center for International Data at the University of California, Davis.[15] Table 4 gives correlations for all of the variables described above as well as average task routineness.

[14] Put differently, satisfaction of the inequality in definition 1 is sufficient but not necessary for sector s to have a higher share of intrafirm trade than sector s'. Accordingly, if our data were not to support proposition 1, it could be either that H_0 does not hold or that the true distributions of tasks cannot be ranked in the sense of definition 1.

[15] http://www.internationaldata.org.

TABLE 4.—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

IV. Estimation and Results

A. 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, then exporter by exporter, it should have a higher share of intrafirm trade. Out of the 141,419 possible comparisons in our data for 2006 (Pair Sectors × Countries), 81,116 have the right signs. In other words, in 57% of all cases, the less routine sector has a higher share of intrafirm trade.[16] 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 5 and 6 present the results of our sign tests using 2006 data broken down by countries and sectors. There is a substantial amount of variation across countries. Success rates of the sign tests range from 38% in Cambodia to 68% in Singapore. Based on these preliminary results, there is little evidence that technological differences, or fragmentation, are a major issue for our approach. The success rates of sign tests in China, India, and Mexico are all above average, at 67%, 64%, and 59%, respectively.

Table 6 shows that there also is a substantial amount of variation across sectors. Success rates range from 30% for "crowns, closures, seals, and other packing accessories" to 80% for "meat products and meat packaging products." Again, there is little evidence that fragmentation affects our results in any systematic manner. For example, success rates are equal to 49% for "aerospace products and parts" but 64% for "electrical equipment and components, nesoi," two sectors for which we would expect fragmentation to occur in practice. Finally, the poor performance of our theory for some sectors, for example, "pulp, paper, and paperboard mill 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.

B. Cross-Sector Regressions

We consider linear regressions of the form

$$\chi_{ct}^s = \alpha_{ct} + \beta\mu^s + \gamma Z^s + \varepsilon_{ct}^s, \tag{9}$$

TABLE 5.—SIGN TESTS, COUNTRY BY COUNTRY, 2006

	Country (N^a)	Sign Test		Country (N^a)	Sign Test
1	Singapore (2,790)	0.68*	29	Portugal (2,697)	0.57*
2	China (2,926)	0.67*	30	Sweden (2,923)	0.57*
3	Thailand (2,916)	0.66*	31	Trinidad (1,845)	0.57*
4	Israel (2,871)	0.65*	32	Vietnam (2,673)	0.57*
5	India (2,898)	0.64*	33	Australia (2,916)	0.56*
6	Germany (2,926)	0.63*	34	Austria (2,905)	0.56*
7	Hong Kong (2,821)	0.63*	35	Indonesia (2,835)	0.56*
8	Ireland (2,835)	0.63*	36	Canada (2,926)	0.55*
9	Italy (2,926)	0.63*	37	Costa Rica (2,790)	0.55*
10	Poland (2,890)	0.63*	38	Netherlands Antilles (1,273)	0.55*
11	United Kingdom (2,926)	0.63*	39	Domican Republic (2,650)	0.54*
12	Finland (2,860)	0.62*	40	Egypt (2,260)	0.54*
13	Denmark (2,923)	0.61*	41	Venezuela (2,548)	0.54*
14	Saudi Arabia (1,495)	0.61*	42	Hungary (2,820)	0.53*
15	Malaysia (2,871)	0.60*	43	New Zealand (2,871)	0.53*
16	Netherlands (2,925)	0.60*	44	Guatemala (2,185)	0.52*
17	Philippines (2,848)	0.60*	45	Colombia (2,806)	0.51
18	South Africa (2,881)	0.60*	46	El Salvador (1,936)	0.50
19	Chile (2,673)	0.59*	47	Pakistan (1,936)	0.50
20	Japan (2,926)	0.59*	48	Sri Lanka (1,979)	0.49
21	Korea (2,916)	0.59*	49	Argentina (2,860)	0.48*
22	Mexico (2,926)	0.59*	50	Bangladesh (1,547)	0.48*
23	Norway (2,835)	0.59*	51	Jamaica (1,440)	0.48
24	Spain (2,925)	0.59*	52	Turkey (2,848)	0.48*
25	Switzerland (2,905)	0.59*	53	Peru (2,223)	0.45*
26	Brazil (2,923)	0.58*	54	Honduras (2,065)	0.41*
27	Macao (1,273)	0.58*	55	Cambodia (909)	0.38*
28	France (2,923)	0.57*			

[a] Number of sector pairs.
* Significant at the 5% level.

where α_{ct} is a country-year 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 intrafirm trade.[17] Therefore, we should observe that $\beta < 0$.

Table 7 presents the OLS estimates of equation (9) for the set of four-digit NAICS manufacturing industries for all years in our sample, with standard errors clustered by industry. In order to allow 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 1-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 main empirical findings of Antràs (2003). Capital intensity and R&D intensity increase the share of intrafirm trade, though the coefficient on capital intensity tends to be significant only at the 10% level.[18] Similarly, our results on the impact of relationship specificity and the dispersion of firm size are consistent with the findings of Nunn and Trefler (2008) and Yeaple (2006), respectively. By contrast, we do not find evidence that intermediation plays a significant role

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[16] In Costinot, Oldenski, and Rauch (2009) we found a success rate of 67% for sectors that could be ranked by first-order stochastic dominance of the distribution of task employment shares, a stronger criterion than ranking by average task routineness.

[17] Formally, if ex ante productivity can be written as $\alpha_c(X, Z^s)$, then ceteris paribus, less routine sectors have a higher share of intrafirm trade.

[18] Antràs (2003) also finds a negative association between skilled labor intensity and the intrafirm import share of a sector. We do not obtain that result after controlling for average task routineness.

TABLE 6.—SIGN TESTS, SECTOR BY SECTOR, 2006

	Sector (N^a)	Test		Sector (N^a)	Test
1	Meat products (3,337)	0.80*	40	Other machinery (4,078)	0.57*
2	Seafood (3,414)	0.77*	41	Springs & wire (3,611)	0.57*
3	Animal foods (3,246)	0.75*	42	Aluminium (3,477)	0.56*
4	Computer equipment (4,115)	0.75*	43	Grain & oilseed milling (3,688)	0.56*
5	Leather tanning (3,451)	0.74*	44	Industrial machinery (3,645)	0.56*
6	Basic chemicals (3,835)	0.70*	45	Iron & steel (3,637)	0.56*
7	Railroad rolling stock (3,252)	0.70*	46	Purchased steel products (3,424)	0.56*
8	Communications equipment (3,804)	0.69*	47	Rubber products (3,818)	0.56*
9	Medical equipment & supplies (3,852)	0.66*	48	Transportation equipment, nesoi (3,396)	0.56*
10	Electrical equipment (3,931)	0.65*	49	Motor vehicle parts (3,982)	0.55*
11	Electrical components, nesoi (4,019)	0.64*	50	Other nonmetallic mineral (3,765)	0.55*
12	Bakeries & tortillas (3,708)	0.63*	51	Beverages (3,675)	0.54*
13	Semiconductors, etc. (4,035)	0.63*	52	Boilers & containers (3,733)	0.54*
14	Fibers, yarns, & threads (3,768)	0.62*	53	Household furniture (3,864)	0.54*
15	Lime & gypsum (3,165)	0.62*	54	Other fabricated metal (4,028)	0.54*
16	Cutlery & handtools (3,742)	0.61*	55	Other wood (3,840)	0.54*
17	Engines & turbines (3,709)	0.61*	56	Textile furnishings (4,022)	0.54*
18	Architectural & structural metals (3,543)	0.61*	57	Agricultural and construction machinery (3,863)	0.53*
19	Converted paper (4,121)	0.60*	58	Engineered wood (3,560)	0.53*
20	Finished fabrics (3,435)	0.60*	59	Paints & adhesives (3,447)	0.53*
21	Other chemical products (3,798)	0.60*	60	Apparel accessories (4,130)	0.52*
22	Petroleum & coal (3,764)	0.60*	61	Foods, nesoi (3,935)	0.52*
23	Pharmaceuticals (3,664)	0.60*	62	Apparel (4,122)	0.51
24	Ships & boats (3,285)	0.60*	63	Motor vehicles (3,287)	0.51
25	Syn rubber & fibers (3,779)	0.60*	64	Pesticides, fertilizers, etc. (3,509)	0.51
26	Audio & video equipment (3,493)	0.60*	65	Cement & concrete (3,440)	0.50
27	Sugar & confectionary (3,616)	0.59*	66	Furniture, nesoi (3,452)	0.50
28	Tobacco products (3,341)	0.59*	67	Motor vehicle bodies (3,280)	0.50
29	Electric lighting equipment (3,659)	0.58*	68	Other leather (4,001)	0.50
30	Fruit & vegetable preserves (3,724)	0.58*	69	Other textiles (4,019)	0.50
31	Hardware (3,543)	0.58*	70	Plastics (4,122)	0.50
32	Bolts, nuts, screws, etc. (3,499)	0.57*	71	Aerospace (3,582)	0.49
33	Clay & refractory (3,906)	0.57*	72	Glass & glass products (3,677)	0.48*
34	Dairy (3,575)	0.57*	73	Foundries (3,469)	0.47*
35	Fabrics (3,995)	0.57*	74	Pulp, paper, & paperboard (3,426)	0.46*
36	Footwear (4,014)	0.57*	75	Magnetic & optical media (3,422)	0.45*
37	Household appliances (3,492)	0.57*	76	Sawmill & wood (3,396)	0.44*
38	Nonferrous (excluding aluminum) (3,565)	0.57*	77	Crowns/closures/seals	0.30*
39	Office furniture (3,602)	0.57*			

[a] Number of sector pairs.
*Significant at the 5% level.

in determining the share of intrafirm imports as in Bernard et al. (2008).

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 7. However, it is about twice as small as the impact of R&D intensity, which is hypothesized to affect the boundary of multinational firms in both knowledge capital and property rights models. Using the specification with the smallest coefficient on routineness as a lower bound, we find that a 1-standard-deviation decrease in the routineness level of a sector leads to a 0.08 standard deviation increase in the share of intrafirm imports, or an additional 2% of total imports that are within the 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.

V. Robustness Checks

A. Technological Differences

In the simple model guiding our empirical analysis, we have assumed that all tasks were aggregated using the same technology, F^s, in all countries. We have also assumed that there was no task intensity reversal, thereby allowing us to use only U.S. data in order to rank our sectors in terms of routineness. As mentioned in section II, this assumption is a strong one in the present context since it rules out situations in which different countries specialize in different tasks through the fragmentation of the production process.

In order to investigate whether our empirical results are sensitive to this assumption, we now rerun our regressions on two subsamples of countries: high-income OECD countries and all other countries.[19] We interpret "high-income OECD" as a proxy for "same technology as in the United States." Accordingly, we expect our results to be stronger in the first subsample of countries since the U.S. ranking of sectors in terms of routineness should be a better proxy for their rankings abroad. Tables 8 and 9 are broadly consistent with

[19] According to the World Bank country classification, high-income OECD countries in our sample are Australia, Austria, Canada, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Japan, Korea, New Zealand, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

TABLE 7.—BASELINE REGRESSIONS

Model :	1	2	3	4	5
N:	29,645	29,645	29,645	29,645	27,775
Routine	−0.183***	−0.082**	−0.086**	−0.090***	−0.083**
	(−6.75)	(−2.21)	(−2.47)	(−2.59)	(−2.48)
Ln(K/L)		0.012	0.058*	0.07*	0.064*
		(0.38)	(1.66)	(1.75)	(1.65)
Ln(S/L)		0.016	0.003	0.005	−0.024
		(0.42)	(0.08)	(0.13)	(−0.67)
Ln(R&D)		0.165***	0.127***	0.136***	0.111***
		(4.22)	(2.88)	(3.06)	(2.70)
Specificity			0.082**	0.084**	0.067
			(2.17)	(2.13)	(1.63)
Intermediation				0.032	0.015
				(0.88)	(0.41)
Dispersion					0.073*
					(1.92)
Fixed effects	Ctry-year	Ctry-year	Ctry-year	Ctry-year	Ctry-year
R^2	0.261	0.281	0.285	0.285	0.292

The dependent variable is the share of intrafirm imports. Standardized beta coefficients reported for pooled data from 2000 to 2006. *, **, and *** indicate significance at the 10%, 5%, and 1% levels. Standard errors are clustered by industry. *T*-statistics are in parentheses.

TABLE 8.—REGRESSIONS FOR HIGH-INCOME OECD COUNTRIES

Model :	1	2	3	4	5
N:	10,780	10,780	10,780	10,780	10,100
Routine	−0.239***	−0.124**	−0.127***	−0.127***	−0.125**
	(−6.22)	(−2.37)	(−2.61)	(−2.60)	(−2.47)
Ln(K/L)		0.051	0.108*	0.107	0.099
		(0.93)	(1.66)	(1.52)	(1.39)
Ln(S/L)		−0.018	−0.035	−0.035	−0.066
		(−0.29)	(−0.59)	(−0.59)	(−1.09)
Ln(R&D)		0.2***	0.154***	0.153***	0.126**
		(3.82)	(2.72)	(2.58)	(2.16)
Specificity			0.100	0.100	0.092
			(1.58)	(1.59)	(1.32)
Intermediation				−0.002	−0.018
				(−0.03)	(−0.30)
Dispersion					0.064
					(1.32)
Fixed effects	Ctry-year	Ctry-year	Ctry-year	Ctry-year	Ctry-year
R^2	0.15	0.18	0.185	0.185	0.185

The dependent variable is the share of intrafirm imports. 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 industry. *T*-statistics are in parentheses.

TABLE 9.—REGRESSIONS FOR ALL OTHER COUNTRIES

Model :	1	2	3	4	5
N:	18,865	18,865	18,865	18,865	17,675
Routine	−0.167***	−0.066	−0.069*	−0.077**	−0.065*
	(−5.24)	(−1.62)	(−1.79)	(−2.00)	(−1.92)
Ln(K/L)		−0.011	0.033	0.055	0.05
		(−0.41)	(0.85)	(1.28)	(1.24)
Ln(S/L)		0.038	0.026	0.029	−0.001
		(1.03)	(0.71)	(0.80)	(−0.04)
Ln(R&D)		0.159***	0.123**	0.138**	0.112**
		(3.58)	(2.50)	(2.79)	(2.37)
Specificity			0.078*	0.082*	0.059
			(1.91)	(1.92)	(1.30)
Intermediation				0.056	0.037
				(1.57)	(0.94)
Dispersion					0.086
					(1.35)
Fixed effects	Ctry-year	Ctry-year	Ctry-year	Ctry-year	Ctry-year
R^2	0.261	0.203	0.206	0.208	0.217

The dependent variable is the share of intrafirm imports. Standardized beta coefficients reported for pooled data from 2000 to 2006. *, **, and *** indicate significance at the 10%, 5%, and 1% levels. Standard errors are clustered by industry. *T*-statistics are in parentheses.

sample if at least two-thirds of intrafirm U.S. imports from that country are imported by U.S.-owned firms. Nunn and Trefler 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 10. In line with the results using the full sample of countries, the coefficient on routineness is negative and statistically significant in all specifications. The results for capital intensity, relationship specificity, intermediation, and dispersion of firm size are also broadly consistent with the baseline results presented in table 7. However, the coefficients on routineness, capital intensity, specificity, and dispersion are less precisely estimated in regressions using this restricted sample of countries.

C. Zero versus Nonzero Trade Flows

The predictions of our simple model apply to both zero and nonzero trade flows. In previous empirical work,

that expectation. Although the coefficients on routineness are negative and significant for both subsets of countries, the magnitudes of these coefficients are greater for high-income OECD countries.

B. U.S.- versus Foreign-Owned Multinationals

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.[20] Since our theoretical framework focuses on the former case, we also run our regressions using the restricted sample of countries proposed by Nunn and Trefler (2008). A country is included in the restricted

[20] A second drawback is that we have data on intrafirm imports only 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.

TABLE 10.—REGRESSIONS FOR RESTRICTED SET OF COUNTRIES

Model :	1	2	3	4	5
N:	15,092	15,092	15,092	15,092	14,140
Routine	−0.149***	−0.063*	−0.066*	−0.074**	−0.064*
	(−5.31)	(−1.65)	(−1.81)	(−2.06)	(−1.95)
Ln(K/L)		−0.017	0.021	0.045	0.041
		(−0.63)	(0.61)	(1.17)	(1.15)
Ln(S/L)		0.029	0.017	0.021	−0.01
		(0.78)	(0.51)	(0.61)	(−0.28)
Ln(R&D)		0.146***	0.115**	0.132***	0.106**
		(3.38)	(2.40)	(2.71)	(2.32)
Specificity			0.067*	0.071*	0.05
			(1.81)	(1.84)	(1.24)
Intermediation				0.061*	0.043
				(1.88)	(1.26)
Dispersion					0.083
					(1.51)
Fixed effects	Ctry-year	Ctry-year	Ctry-year	Ctry-year	Ctry-year
R^2	0.218	0.236	0.238	0.24	0.251

The dependent variable is the share of intrafirm imports. Standardized beta coefficients reported for pooled data from 2000 to 2006. *, **, and *** indicate significance at the 10%, 5%, and 1% levels. Standard errors are clustered by industry. *T*-statistics are in parentheses.

TABLE 11.—REGRESSIONS ONLY, INCLUDING NONZERO INTRAFIRM IMPORT SHARES

Model :	1	2	3	4	5
N:	21,679	21,679	21,679	21,679	20,339
Routine	−0.214***	−0.077**	−0.081**	−0.072**	−0.073**
	(−7.50)	(−2.14)	(−2.56)	(−2.24)	(−2.23)
Ln(K/L)		0.071*	0.14**	0.118**	0.115**
		(1.91)	(2.57)	(2.16)	(2.10)
Ln(S/L)		−0.017	−0.044	−0.048	−0.064
		(−0.34)	(−0.90)	(−1.01)	(−1.31)
Ln(R&D)		0.213***	0.165***	0.147***	0.134***
		(5.19)	(3.74)	(3.58)	(3.51)
Specificity			0.113**	0.111**	0.112*
			(2.06)	(2.15)	(1.95)
Intermediation				−0.06*	−0.066*
				(−1.75)	(−1.92)
Dispersion					0.021
					(0.69)
Fixed effects	Ctry-year	Ctry-year	Ctry-year	Ctry-year	Ctry-year
R^2	0.202	0.235	0.242	0.244	0.243

The dependent variable is the share of intrafirm imports. Standardized beta coefficients reported for pooled data from 2000 to 2006. *, **, and *** indicate significance at the 10%, 5%, and 1% levels. Standard errors are clustered by industry. T-statistics are in parentheses.

however, Bernard et al. (2008) have shown that the impact of country and sector characteristics on the share of intrafirm imports may be very different at the extensive and intensive margins. For example, they document that the quality of country governance increases the probability of intrafirm trade but decreases the share of intrafirm trade conditional on intrafirm trade flows being positive. To assess whether such "selection" effects may bias our empirical results, we rerun our baseline regressions using only observations with a strictly positive share of intrafirm imports. The results are presented in table 11. The coefficients on routineness remain significant and similar in magnitude to those obtained using both zero and nonzero valued observations.

VI. 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 Network. Using both nonparametric 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 1-standard-deviation decrease in average routineness raises the share of intrafirm imports by 0.08 standard deviations, or an

additional 2% 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.

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