Buyer Investment, Product Variety, and Intrafirm Trade

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Abstract: This paper studies a simple model of buyer investment and its effect on the variety and vertical structure of international trade. A distinction is made between two types of buyer investment: "flexible" and "specific". Their interactions with the entry and pricing incentives of suppliers are analyzed. It is shown that (i) there can be multiple equilibria in the variety of products traded, and (ii) less product variety is associated with more intrafirm trade. The possibility of multiple equilibria is consistent with the observation that some similar economies, such as Taiwan and South Korea, differ substantially in their export varieties to the U.S. A formal empirical analysis confirms the negative correlation between product variety and intrafirm trade.

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1. INTRODUCTION

Recent literature in international trade has emphasized the importance of contractual relationships between firms, and sought to explain these contractual relations by features of the industries and host countries. For example, Antràs (2003) argues that in more capital-intensive industries, a greater share of trade is intrafirm, i.e. between a parent and its subsidiaries. Antràs and Helpman (2003) analyze a more general multi-industry, multi-country model, where the type of contracts and ownership between firms will depend on features of the industry (the productivity distribution of firms) as well features of the host countries (such as factors prices). Similarly, Nocke and Yeaple (2004) solve for the locational choice of foreign direct investment (FDI) by matching characteristics of the companies and the host countries.

Missing from this literature, however, is a consideration of the buyers in the destination market. Gary Gereffi (1994; Gereffi and Lin 1994) uses the term "big buyers" to refer to the mass merchandisers in the United States who, he argues, have influenced the organization of production in Asia. As a specific example, consider South Korea and Taiwan. While these two countries export in many of the same broad industry categories, the details of their trade are quite different. South Korea is well-known for trying to achieve "world status" in products such as cars, microwaves, consumer electronics, dynamic random access memories (DRAMs) and other mass-produced goods. The business groups selling these goods – such as Hyundai, Samsung and Daewoo – have become household names in the U.S. and worldwide. Taiwan, by contrast, focuses more on intermediate inputs and customized products, selling auto parts and bicycles rather than cars, more customized chips than DRAMs, women's fashions as opposed to men's shirts, etc. Many of these goods are produced under OEM (original equipment manufacturer) arrangements for retailers overseas, who typically require customized designs. This is one explanation for the finding that Taiwan exports a great variety of products to the U.S. than does South Korea in many industries (Feenstra, Yang, and Hamilton, 1999).

Feenstra and Hamilton (2004) have recently argued that the differential export patterns from South Korea and Taiwan are at least in part the result of *increased demand* generated by regulatory changes in the United States. Specifically, the repeal of "fair trade laws" in the United States during the 1960s allowed for huge increase in mass-merchandising, orchestrated by the merchandisers acting as intermediaries between U.S. consumers and Asian producers. This increase in U.S. demand occurred just as Korea and Taiwan were in a position to meet that demand; but that it was exercised in different market segments within the two countries. Buyers began to look to Korea for the provision of long production runs of relatively standardized products, whereas Taiwan supplied shorter production runs of more specialized, niche products. Thus, the exercise of international demand resulted in quite different product varieties from each country.

To examine this hypothesis, we propose a simple model of how buyers can influence product variety. In particular, we consider how buyer investment on input requirements can affect the variety and vertical structure of trade for intermediate goods. The recent literature on the organization of international trade tends to focus on situations where sellers make investments (e.g., McLaren, 2000; Antràs, 2003);[1] our focus on buyer investment complements this literature. Our basic model, described in section 2, is the familiar circle of product varieties, with upstream suppliers arranging themselves at discrete intervals. Downstream buyers have a preferred specification of the good, but can incur an investment allowing them to more easily adapt to different specifications that are not their preferred. Such "flexible" investment, however, reduces the incentives for upstream entry and results in fewer upstream varieties. This tension between upstream variety and downstream flexibility can give rise to *multiple equilibria* in the economic organization: downstream buyers make flexible investment and upstream suppliers produce fewer varieties; or downstream

[1] Models in the theory of contracts and firms also tend to focus more on the investment incentives of the sellers, but investment incentives by buyers clearly have also received attention, as, for instance, in the general framework of Grossman and Hart (1986), and in the empirical work of Joskow (1987) where downstream power plants can make asset-specific investment by locating closer to coal mines.

buyers make no flexible investment and upstream suppliers produce more varieties.[2] One interesting implication of this model is that it provides an explanation for the different export market structures of South Korea and Taiwan, if we interpret the equilibrium with fewer varieties as applying to Korea, and the equilibrium with more varieties as applying to Taiwan.

In Section 3, we extend the basic model by allowing each downstream buyer to have the additional option of making a “specific" investment that would match its preferred specification with a particular supplier's (i.e., increasing the buyer's match quality with a particular supplier). In the equilibrium with more varieties, a buyer can expect its input needs to be matched relatively well by a supplier, and thus there is lower benefit to make the specific investment ex ante; the opposite is true in the equilibrium with fewer varieties. As it turns out, more buyers can potentially benefit from the specific investment in the equilibrium with fewer varieties. However, there is an important distinction between a buyer's specific investment and flexible investment: while the flexible investment reduces suppliers' market power, the specific investment increases their market power and can create the familiar hold-up problem. Vertical integration between buyers and suppliers can serve as a mechanism to overcome the hold-up problem and realize the gains from specific investment. Consequently, in the equilibrium with low varieties, where the gains from specific investment are higher, there is more vertical integration, or more intrafirm trade. The consideration of the two types of buyer investment, and of their interactions with the entry and pricing incentives of suppliers, can thus lead to an equilibrium theory of variety and vertical structure in international trade. The central prediction of this theory is that there is a negative correlation between variety and intrafirm trade.

At an aggregate level, we know that this prediction is true for South Korea and Taiwan: Zeile (2003, Table 2B) reports that for U.S. imports in 1997, only 9.8% of goods coming from Taiwan were intrafirm purchases from their foreign parent groups, whereas 32.8% of

[2] The flexible-investment-low-variety equilibrium or the no-investment-high-variety equilibrium can also occur as the unique equilibrium of the model in mutually exclusive regions of parameter values.

goods coming from Korea where intrafirm purchases.[3] The goal of our empirical work in sections 4-6 is to explore this connection between product variety and intrafirm trade for a broader sample of countries, as used by Antràs (2003). He finds that countries with more capital-intensive exports are more likely to engage in intra-firm trade across borders. Along with capital intensity, we add the countries' export variety as an explanatory variable,[4] or more precisely, the unexplained portion of export variety from that predicted from a gravity equation. We find that this variable is negatively correlated with intrafirm exports, as expected from our theory. Conclusions and directions for further research are discussed in Section 7.

2. THE BASIC MODEL

There are two countries, home (H) and foreign (F). There is a continuum of m firms in H, each of which needs to purchase 1 unit of an input from F. Each home firm's input has an ideal characteristic that is represented by a point on a circle of unit perimeter length. In purchasing the input, the firm incurs an adjustment cost that is the product of τ and the distance between its ideal point and the location of its supplier along the circle. Thus τ is the unit adjustment (transportation) cost, which is a measure of how flexible the downstream firm is in its input requirement (or how easily the downstream firm can substitute its input between different suppliers). A downstream firm can invest (I) to increase the flexibility of its input requirement. In particular, we assume:

$$\tau = \begin{cases} \tau_h & if \quad I = 0 \\ \tau_l & if \quad I = k > 0 \end{cases},$$

[3] For the 1992 benchmark survey (Zeile, 1997, Table 6) reports that 4.5% of the goods coming from Taiwan were intra-firm purchases from their foreign parent groups, whereas 21% of the goods coming from Korea were intra-firm purchases. Evidently, the extent of intra-firm exports from both Taiwan and Korea has been growing.

[4] As in Antràs (2003), we examine these contries' exports to the U.S., and thus the variable is the same as the U.S. import variety from these countries.

where $0 < \tau_l < \tau_h$. For instance, k could be an investment in a technology that allows greater input substitutability. Alternatively, k may be an investment that reduces transaction costs with potential suppliers, such as setting up an office in F.[5] Ex ante, each firm's ideal point is a random variable uniformly distributed on the circle. Downstream firms in H will also be called buyers.

There is a large number of potential suppliers (upstream firms) in the foreign country. Each of them can choose to enter the market with entry cost $f > 0$ and produce the input with constant marginal cost $c \geq 0$. The game, in which only pure strategies will be considered, is as follows:

- Stage 1. Potential suppliers simultaneously make entry decisions, and choose locations on the circle if entry occurs.
- Stage 2. Each downstream firm in H decides whether to invest k to increase its flexibility in dealing with different suppliers.
- Stage 3. The downstream firms' locations (ideal points) on the circle are realized. The suppliers who have entered the market, observing downstream firms' locations and whether they have invested k, simultaneously bid prices to the downstream firms.
- Stage 4. Each downstream firm accepts the offer with the lowest purchasing cost (price plus adjustment cost), and the input is produced.[6]

We start our analysis by considering the situation where $n \geq 2$ suppliers are located on the circle with equal distance from each other. Without loss of generality, we let supplier 1 be located at the bottom of the circle and number suppliers and buyers in the clockwise order. A buyer's location is characterized by x_i, which means that the buyer is located immediately ahead of supplier i and its distance from i is x_i. We denote supplier i by *Ui.*

[5] The investment could also be on the organization/marketing of production. If the downstream firms are retailers, for instance, by investing in large discount stores (shopping malls) and adopting mass retailing, the downstream firms may desire more standardized products with lower costs.

[6] The downstream firms are assumed to value the input sufficiently high so that the input is always purchased in equilibrium.

Given any $\tau \in \{\tau_h, \tau_l\}$, any x_i will effectively face two competing suppliers, i and $i+1$ for $i = 1, ..., n-1$, or i and 1 for $i = n$. The marginal customer for supplier i is $x_i = \frac{1}{2n}$. If $x_i < \frac{1}{2n}$, supplier i has a competitive advantage in serving x_i and will supply x_i at price p_i, where

$$p_i + \tau x_i = c + \tau \left(\frac{1}{n} - x_i \right).$$

The Bertrand-Nash equilibrium price of firm i for buyer x_i is:

$$p_i(x_i) = \max \left\{ c, \; c + \tau(\frac{1}{n} - 2x_i) \right\}.$$

Supplier i's equilibrium profit, taking into account the potential buyers on its right side as well, is thus

$$\pi_i = m2 \int_0^{\frac{1}{2n}} \left(c + \tau(\frac{1}{n} - 2x_i) - c \right) dx_i - f = m\frac{1}{2n^2}\tau - f.$$

In a free-entry (zero-profit) equilibrium, we have

$$\hat{n} = \sqrt{m\frac{\tau}{2f}}, \tag{1}$$

provided that $m \geq \frac{8f}{\tau}$, which ensures $\hat{n} \geq 2$. For the rest of the paper we assume $m \geq \frac{8f}{\tau}$.

A buyer's expected price when there are n suppliers is

$$2n \int_0^{\frac{1}{2n}} p_i(x_i)\, dx_i = 2n \int_0^{\frac{1}{2n}} \left(c + \tau(\frac{1}{n} - 2x_i) \right) dx_i = c + \frac{\tau}{2n}.$$

The buyer's expected cost of purchasing the input when there are n suppliers is

$$2n \int_0^{\frac{1}{2n}} (p_i(x_i) + \tau x_i)\, dx_i = 2n \int_0^{\frac{1}{2n}} \left(c + \tau(\frac{1}{n} - 2x_i) + \tau x_i \right) dx_i = c + \frac{3\tau}{4n}.$$

When $n = \hat{n}$, the buyer's expected cost of purchasing the input is

$$\hat{p} = c + \frac{3\tau}{4\sqrt{m\frac{\tau}{2f}}} = c + \frac{3}{2}\sqrt{\frac{\tau f}{2m}}.$$

We next provide the justification for our focus on an upstream market structure in which all suppliers have the same distance from each other, with the following result concerning the location choices of suppliers at any subgame perfect equilibrium of the game:

Lemma 1 *In equilibrium, all suppliers must be equally distanced from each other.*

Proof. We consider the two cases where $n = 2$ and $n \geq 3$ separately. It suffices to assume that all buyers have the same τ, since, same as the entire buyer population, any possible fraction of buyers with τ_h or τ_l will also be uniformly distributed on the circle.

Case 1: $n = 2$. Suppose first that U2's distance from U1 is $y \leq \frac{1}{2}$ clockwise. For any consumer x_1 and x_2, the equilibrium prices of U2 are

$$\begin{aligned} p_2(x_1) &= \max\{c,\ c + \tau(2x_1 - y)\}, \\ p_2(x_2) &= \begin{cases} c + \tau y & if \quad 0 \leq x_2 \leq \frac{1}{2} - y \\ \max\{c,\ c + \tau(1 - y - 2x_2)\} & if \quad \frac{1}{2} - y < x_2 \leq \frac{1-y}{2} \end{cases}. \end{aligned}$$

U2's profit is the same as U1's and is equal to

$$\begin{aligned} \pi(y) &= \int_{\frac{y}{2}}^{y} (c + \tau(2x_1 - y) - c)\, dx_1 + \int_0^{\frac{1}{2}-y} (c + \tau y - c)\, dx_2 \\ &\quad + \int_{\frac{1}{2}-y}^{\frac{1-y}{2}} (c + \tau(1 - y - 2x_2) - c)\, dx_2 \\ &= -\frac{1}{2}y^2\tau + \frac{1}{2}y\tau. \end{aligned}$$

Thus

$$\pi'(y) = -\tau y + \frac{1}{2}\tau$$

and hence in equilibrium y must be

$$y^* = \frac{1}{2}.$$

Similar $y^* = \frac{1}{2}$ if we assume $y \geq \frac{1}{2}$.

Case 2: $n \geq 3$. Suppose that the distance of supplier $i + 1$ to i is y, and its distance to supplier $i + 2$ is $l - y$. It suffices to show that in equilibrium $y = \frac{l}{2}$, since this would imply that there can be no equilibrium where suppliers are not located in equal distance to each other, and furthermore by letting $l = \frac{2}{n}$ it is an equilibrium for firms to locate in equal distance to each other.

With reasoning similar to that in Case 1, we can assume $y \leq \frac{l}{2}$ and write the equilibrium profit of supplier $i+1$ as

$$\begin{aligned}
\pi_{i+1}(y) &= \int_{\frac{y}{2}}^{y} (c + \tau(2x - y) - c)\, dx + \int_{0}^{\frac{l}{2}-y} (c + \tau y - c)\, dx \\
&\quad + \int_{\frac{l}{2}-y}^{\frac{l-y}{2}} (c + \tau(l - y - 2x) - c)\, dx \\
&= -\frac{1}{2} y^2 \tau + \frac{1}{2}\tau l y.
\end{aligned}$$

Thus

$$\pi'_{i+1}(y) = -y\tau + \frac{1}{2}\tau l$$

and hence in equilibrium

$$y^* = \frac{l}{2}.$$

■

We are now ready to establish the main result of the basic model. Define

$$n_j = \sqrt{\frac{m\tau_j}{2f}} \qquad \text{for } j = h, l.$$

Then, since $\tau_l < \tau_h$, we have $n_l < n_h$.

Proposition 1 *In equilibrium of the basic model:*

(1) If $k > \frac{3}{4}\frac{\tau_h - \tau_l}{n_l} \equiv \bar{k}$, then $I^* = 0$, $\tau^* = \tau_h$, and $n^* = n_h$.

(2) If $k < \frac{3}{4}\frac{\tau_h - \tau_l}{n_h} \equiv \underline{k}$, then $I^* = k$, $\tau^* = \tau_l$, and $n^* = n_l$.

(3) If $\underline{k} \leq k \leq \bar{k}$, then there exist two equilibria: $I^* = 0$, $\tau^* = \tau_h$, and $n^* = n_h$; and $I^* = k$, $\tau^* = \tau_l$, and $n^* = n_l$.

Proof. First, from Lemma 1, suppliers will locate in equal distance from each other in equilibrium.

Next, if $I = 0$ and hence $\tau = \tau_h$, then $n = n_h$ from the derivation of $\hat{n}$ given in equation (1). Thus it is an equilibrium for $I^* = 0$, $\tau^* = \tau_h$ and $n^* = n_h$ if and only if, given n_h, any downstream firm has no incentive to invest k, or

$$c + \frac{3\tau_h}{4n_h} - \left(c + \frac{3\tau_l}{4n_h} + k \right) \leq 0,$$

or

$$k \geq \frac{3}{4}\frac{\tau_h - \tau_l}{n_h} \equiv \underline{k}.$$

Next, if $I = k$ and hence $\tau = \tau_l$, then $n = n_l$ from the derivation of $\hat{n}$ given in equation (1). Thus it is an equilibrium for $I^* = k$, $\tau^* = \tau_l$ and $n^* = n_l$ if and only if, given n_l, any downstream firm has no incentive to invest 0, or

$$\frac{3\tau_l}{4n_l} + k \leq \frac{3\tau_h}{4n_l}.$$

That is,

$$k \leq \frac{3}{4}\frac{\tau_h - \tau_l}{n_l} \equiv \bar{k}.$$

Finally, since $n_l < n_h$,we can divide k into the three mutually exclusive intervals on which statements (1)-(3) hold.

■

Thus, for similar economies, there can be two different market structures in their exports: one with a relatively large number of small suppliers and of varieties, each supplier producing a small quantity; and another with a smaller number of larger suppliers and fewer varieties, each supplier producing a larger quantity. This provides an explanation of the different market structures of export sectors in South Korea and Taiwan. When buyers become more flexible in their input requirements, there are less incentive for variety and more incentive for lowering average cost in the upstream industry. This seems to be the case for Korea, where buyers from the US looked for long production runs of relatively standardized products. In the case for Taiwan, international buyers appeared to have demanded shorter production runs of more specialized, niche products; and this provides incentive for more upstream entry and the provision of more varieties. Our analysis captures an interesting tension between upstream variety and downstream flexibility, which has not been noticed in the literature before.

While the circle model is well known in the product differentiation literature, ours has two distinctive features, namely τ can be changed through investment and the locations of buyers are observed by sellers in price competition. These features seem especially natural in the intermediate-goods market, where the identities of buyers are usually known by suppliers, and where a buyer is likely to be able to invest in technologies or to make arrangements that affect the cost to change suppliers.[7] Our analysis would essentially be the same if the locations of the downstream firms are not observable, except that the equidistant locations of the suppliers would need a justification that is different from our proof for Lemma 1.[8] An advantage of our formulation is that the location choices of firms (locating equidistantly) is established as the equilibrium outcome of the game with linear transportation cost.

The expected procurement cost of a representative downstream firm is given by

$$z = \begin{cases} c + \frac{3\tau_h}{4n_h} & if \quad I^* = 0 \text{ and } n^* = n_h \\ c + \frac{3\tau_l}{4n_l} + k & if \quad I^* = k \text{ and } n^* = n_l \end{cases}.$$

Thus, the equilibrium procurement cost is lower without k if and only if

$$k > \frac{3\tau_h}{4n_h} - \frac{3\tau_l}{4n_l}.$$

Notice that

$$\underline{k} - \left(\frac{3\tau_h}{4n_h} - \frac{3\tau_l}{4n_l}\right) = \frac{3}{4}\frac{\tau_h - \tau_l}{n_h} - \left(\frac{3\tau_h}{4n_h} - \frac{3\tau_l}{4n_l}\right) = \frac{3\tau_l}{4}\left(-\frac{1}{n_h} + \frac{1}{n_l}\right) > 0.$$

Hence, if the procurement cost is lower with $I = k$, or $k \leq \frac{3\tau_h}{4n_h} - \frac{3\tau_l}{4n_l}$, we must have $k < \underline{k}$ as well and in equilibrium $I^* = k$. On the other hand, if the procurement cost is lower with $I = 0$, or $k > \frac{3\tau_h}{4n_h} - \frac{3\tau_l}{4n_l}$, it is possible that in equilibrium we still have $I^* = k$. This inefficient "over-investment" by the buyers occurs as the unique equilibrium outcome if

$$\frac{3\tau_h}{4n_h} - \frac{3\tau_l}{4n_l} < k < \underline{k},$$

[7] The considerations here are related to the approach in Chen (forthcoming), who studies the incentives for, and effects of, marketing innovations by producers of final goods that increase their abilities to gather consumer information or reduce consumer transaction costs.

[8] To our knowledge, in the literature on product differentiation, the equidistant result in the circle model has been shown as the equilibrium of a location game only with quadratic transportation costs.

and can occur as one of the equilibria if

$$\underline{k} \leq k \leq \bar{k}.$$

We therefore have:

Corollary 1 *In equilibrium, downstream firms' choice of I^*, the input flexibility investment, minimizes their procurement cost if*

$$\text{either } k \leq \frac{3\tau_h}{4n_h} - \frac{3\tau_l}{4n_l} \text{ or } k > \bar{k}.$$

Otherwise $I^* = k$ can occur in equilibrium but downstream firms' procurement costs are not minimized.

Interestingly, while the ability to invest in the flexibility of input requirements can benefit the buyers, sometimes it also makes them worse off. Such investment intensifies competition among suppliers and reduces their rents that are necessary to cover their entry costs. For fear of this, there will be less entry of suppliers, resulting in less variety in the intermediate-goods market and less competition there, which makes it indeed desirable for the downstream buyers to invest in the flexibility of input requirements. The inefficiency arises since the flexible investment by the buyers has a negative externality on the upstream suppliers, which the buyers do not internalize. In equilibrium, the suppliers correctly anticipate this and reduce entry. The problem is that buyers cannot commit not to invest k. Such commitment, for instance, would not be possible if contracting for k is not feasible.

3. SPECIFIC INVESTMENT AND VERTICAL STRUCTURE

In our basic model, the upstream and downstream firms are by assumption independently owned. We now extend the basic model to allow the vertical structure in international trade to be determined endogenously, so that in equilibrium some firms may be vertically integrated. We modify Stage 2 of the basic model as follows: At Stage 2, each downstream firm first learns to which upstream firm it is located closest (or, equivalently, which one of the segments of length $\frac{1}{2n}$ on the circle it belongs to), even though its precise location is not realized until Stage 3. Second, each downstream firm can invest s to position its ideal point at the location of the supplier to which it is located closest, where s is the realization of a continuous random variable with c.d.f. $G(s)$ on support $[\underline{s},\ \bar{s}]$, and we assume $0 < \underline{s} \leq \frac{\tau_h}{4n_h} < \frac{\tau_l}{4n_l} + k < \bar{s}$.[9] Third, the upstream firm is unable to commit to any price that it will charge the downstream firm, but it can vertically integrate with the downstream firm.[10] Fourth, the downstream firm can still invest k if it wishes. Everything else in this extended model is the same as in the basic model.

It is immediately clear that, if no downstream firm invests s, the analysis and the equilibrium of the game will be exactly the same as in the previous section. In particular, since the expected procurement cost for any buyer on any of the segments of length $\frac{1}{2n}$ is the same, knowing which segment it belongs to will not change the buyer's decision on whether or not to invest k.

If in equilibrium $n^* = n_l$, then the expected procurement cost of a downstream firm without investing s is

$$\begin{aligned} 2n_l \int_0^{\frac{1}{2n_l}} \left(p_i\left(x_i\right) + \tau_l x_i\right) dx_i + k &= 2n_l \int_0^{\frac{1}{2n_l}} \left(c + \tau_l(\frac{1}{n_l} - 2x_i) + \tau_l x_i\right) dx_i + k \\ &= c + \frac{3\tau_l}{4n_l} + k. \end{aligned}$$

If

$$s + c < c + \frac{3\tau_l}{4n_l} + k - 2n_l \int_0^{\frac{1}{2n_l}} \left(p_i\left(x_i\right) dx_i - c\right) = c + \frac{\tau_l}{4n_l} + k,$$

or

$$s < \frac{\tau_l}{4n_l} + k,$$

[9] This is a crude way of introducing the idea that a buyer can invest to increase her match quality with a particular supplier, for instance, through adjusting its input requirement, adopting a particular technology, providing specific employee training, or marketing efforts promoting the supplier's product.

[10] We assume that vertical integration can possibly occur only if at least one party strictly benefits from it, even though for simplicity we assume that there is no additional cost associated with vertical integration. We can easily add a cost for vertical integration and reduce s by this cost, without changing the result of our analysis.

then investing s (and not investing k) will lead to a higher joint surplus between the pair of upstream and downstream firms. However, if the downstream firm invests s, it will be subject to the well-known hold-up problem since the upstream firm has not committed to the price it will charge. Because the downstream firm making the specific investment will be further away from other upstream firms, it expects to pay a higher price *ex post*. Thus, absent of vertical integration, s will not be invested. Vertical integration can solve this hold-up problem and realize the potential gains from the specific investment. Under vertical integration, for convenience we assume that the downstream firm sells the business to the upstream firm by making a take-it-or-leave-it offer, which ensures that vertical integration will not change the expected earnings of the upstream firms and hence not change the equilibrium number of upstream firms. This is because under this assumption, the upstream firm's payoff from merging with the downstream firm will be

$$\tilde{\pi}_i = \int_0^{\frac{1}{2n}} (p_i(x_i) - c)\, 2n dx_i = \int_0^{\frac{1}{2n}} \left(c + \tau_l(\frac{1}{n} - 2x_i) - c \right) 2n dx_i = \frac{\tau_l}{2n},$$

which is the same as its expected earnings from any downstream firm who is within the $\frac{1}{2n}$ distance and who does not invest s (but invests k, consistent with $n^* = n_l$). Therefore, if in equilibrium $n^* = n_l$, a mass of $mG\left(\frac{\tau_l}{4n_l} + k\right)$ buyers will vertically integrate with suppliers, or $mG\left(\frac{\tau_l}{4n_l} + k\right)$ amount of the export from F to H will be intrafirm trade.

Next, if in equilibrium $n = n_h$, then the expected procurement cost of a downstream firm without investing s is

$$\begin{aligned} 2n_h \int_0^{\frac{1}{2n_h}} (p_i(x_i) + \tau_h x_i)\, dx_i &= 2n_h \int_0^{\frac{1}{2n_h}} \left(c + \tau_h(\frac{1}{n_h} - 2x_i) + \tau_h x_i \right) dx_i \\ &= c + \frac{3\tau_h}{4n_h}. \end{aligned}$$

Vertical integration (together with investing s by a downstream firm) will occur if and only if

$$s + c < c + \frac{3\tau_h}{4n_h} - \left(2n_h \int_0^{\frac{1}{2n_h}} p_i(x_i)\, dx_i - c \right) = c + \frac{\tau_h}{4n_h},$$

or

$$s < \frac{\tau_h}{4n_h}.$$

Thus, if in equilibrium $n^* = n_h$, a mass of $mG\left(\frac{\tau_h}{4n_h}\right)$ buyers will vertically integrate with suppliers, or $mG\left(\frac{\tau_h}{4n_h}\right)$ amount of the export from F to H will be intrafirm trade. Since

$$\begin{aligned}\underline{k} - \frac{1}{4}\left(\frac{\tau_h}{n_h} - \frac{\tau_l}{n_l}\right) &= \frac{3}{4}\frac{\tau_h - \tau_l}{n_h} - \left(\frac{\tau_h}{4n_h} - \frac{\tau_l}{4n_l}\right) = \frac{1}{2}\frac{\tau_h}{n_h} - \tau_l\left(\frac{3}{4}\frac{1}{n_h} - \frac{1}{4n_l}\right) \\ &> \frac{1}{2}\frac{\tau_h}{n_h} - \tau_l\left(\frac{3}{4}\frac{1}{n_l} - \frac{1}{4n_l}\right) = \frac{1}{2}\left(\frac{\tau_h}{n_h} - \frac{\tau_l}{n_l}\right) \\ &= \frac{1}{2}\left(\frac{\tau_h}{\sqrt{\frac{m\tau_h}{2f}}} - \frac{\tau_l}{\sqrt{\frac{m\tau_l}{2f}}}\right) = \sqrt{\frac{f}{2m}}\left(\sqrt{\tau_h} - \sqrt{\tau_l}\right) > 0,\end{aligned}$$

and $k > \frac{\tau_h}{4n_h} - \frac{\tau_l}{4n_l}$ by assumption[11],using results from Proposition 1, we have:

Proposition 2 *In equilibrium of the extended model:*

(1) If $k > \bar{k}$, then the high-variety-low-integration equilibrium prevails, in which: $I^* = 0$, $\tau^* = \tau_h$, $n^* = n_h$; $mG\left(\frac{\tau_h}{4n_h}\right)$ buyers vertically integrate with suppliers and invest s, and the rest of buyers remain vertically separated and do not invest s.

(2) If $\frac{1}{4}\left(\frac{\tau_h}{n_h} - \frac{\tau_l}{n_l}\right) < k < \underline{k}$, then the low-variety-high-integration equilibrium prevails, in which: $n^* = n_l$; $mG\left(\frac{\tau_l}{4n_l} + k\right)$ buyers vertically integrate with suppliers, invest s, and set $I^* = 0$; while the rest of buyers remain vertically separated, do not invest s, and choose $I^* = k$.

(3) If $\underline{k} \leq k \leq \bar{k}$, then the equilibrium can be either the high-variety-low-integration equilibrium or the low -variety-high-integration equilibrium.

The central point of Proposition 2 is that there will be more vertical integration, or more intrafirm trade of the intermediate good, at the equilibrium with $n^* = n_l$ than at the equilibrium with $n^* = n_h$. In other words, if the upstream industry has fewer firms or produces less variety, there will be more vertical integration or intrafirm trade. This result holds whether the parameter values of the model are such that there is a unique equilibrium or there are multiple equilibria. Intuitively, the specific investment allows a

[11] This assumption is not needed if we are only concerned with multiple equilibria for the same industry, since multiple equilibria can arise only if $k \geq \underline{k}$, and $\underline{k} > \frac{\tau_h}{4n_h} - \frac{\tau_l}{4n_l}$. For comparisons of different industries, this assumption requires that k is not too small relative to $\left(\sqrt{\tau_h} - \sqrt{\tau_l}\right)$.

buyer to improve its match quality with a particular supplier. When the number of upstream firms is large, any downstream firm can expect its input needs to be matched relatively well by an upstream firm, and thus there is relatively low benefit to make the specific investment. On the other hand, when the number of upstream firms is low, a downstream firm expects to incur more substantial adjustment cost to meet its input requirement, and thus there is high benefit from the specific investment. Consequently, in the latter case, the marginal downstream firm who can potentially benefit from making specific investment corresponds to a higher s, implying that there are more such downstream firms.[12] However, while the flexible investment reduces the expected price for the downstream firm *ex post*, the specific investment raises the expected price of the downstream firm *ex post* due to the hold-up problem. Vertical integration between upstream and downstream firms is needed as a mechanism to solve the hold-up problem and realize the gains from specific investment.

Our assumption that the downstream firms appropriate all the gains from vertical integration significantly simplifies the analysis. Under this assumption the upstream firms will receive the same payoff in this extended model as in the basic model (with or without vertical integration), so the incentive for entry in the upstream market is not changed; as a result, there is no change for the conditions on k for the equilibrium number of suppliers. If the upstream firms' payoffs increase as a result of vertical integration, there will be additional upstream entry in equilibrium; this will complicate the analysis, but need not change the qualitative nature of our results.

Proposition 2 offers a testable prediction about product variety and intrafirm trade: export (or import) variety is negatively correlated with intrafirm trade. We next test this predication empirically.

[12] The downstream firm can also invest k to increase its input requirement flexibility, resulting a lower τ; but specific investment that matchs its input requirement with an upstream firm can result in more cost savings when s is below $\frac{\tau_l}{4n_l} + k$.

4. EMPIRICAL SPECIFICATION AND DATA

To test the hypotheses developed above, we make use of the data in Antràs (2003), who considered intrafirm imports from 28 countries to the United States, in 1992. He used Bureau of Economic Analysis (BEA) data to construct intrafirm imports to the U.S. in manufacturing industries. His hypothesis was that intrafirm imports should be higher in capital-intensive industries or from capital-abundant countries, which was supported by the regressions that he runs. In addition to the capital-intensity of industries, Antràs controls for factors such as human capital, corporate tax rates, and the openness of countries to trade and FDI.

Our key hypothesis is that a higher product variety of imports, such as coming from Taiwan as compared to Korea in their sales to the U.S., is associated with lower intrafirm imports. In order to test this hypothesis, however, it is important to control for other factors that influence import variety. Simple proximity of a country to the U.S., as well as sheer size of a country, will both lead to higher variety. We can control for these factors by first estimating a gravity equation where the dependent variable is import variety to the U.S., by partner country. The residuals from this gravity equation will then be used as an explanatory variable for intrafirm imports, in regressions that also include the capital-abundance of countries and other explanatory variables used by Antràs.

The measurement of import variety follows closely the approach of Feenstra (1994). He develops a measure of product variety that is consistent with a CES aggregator function, even when that function is not symmetric across goods. This measure of product variety has been utilized recently by Borda and Weinstein (2004), for example, who consider the increasing variety of imports coming into the United States. Hummels and Klenow also use the CES measure of trade variety, and call it the "extensive margin" of a country's exports (as contrasted with the "intensive margin," which would be the quantity of exports rather then variety). Feenstra and Kee (2004) have recently studied how export variety from various countries to the U.S. impacts those country's aggregate productivity.

In the next section we provide some details on the CES measure of import variety, which we measure for 114 countries selling to the U.S. in 1992 (the year of Antràs' data) and 1997. The later year is added since measures of intra-firm imports for the U.S. in 1997 are now available from the BEA (Zeile, 2003), but these data were not available to Antràs (2003). Thus, we are able to double the size of the dataset used for estimation. The BEA reports data on imports shipped by overseas affiliates to their U.S. parents, and imports shipped to U.S. affiliates by their foreign parent groups. Following Antràs, we focus on the sum of these two series for majority-owned affiliates. Unlike Antràs, however, we do no necessarily restrict ourselves to manufacturing industries. In addition to using that measure of intrafirm-trade, we also consider intrafirm sales to manufacturing and wholesale industries. Therefore, we will have two different measures of intrafirm imports (using just manufacturing or using manufacturing plus wholesale industries) and two years of country observations (1992 and 1997).

5. MEASUREMENT OF IMPORT VARIETY

Let p_t^c denote the value of a CES unit-cost function defined over the prices of all product varieties sold into the U.S. by country c:

$$P_t^c \equiv \left(\sum_{i \in I_t^c} b_i \left(p_{it}^c\right)^{1-\sigma} \right)^{1/(1-\sigma)}, \; b_i = a_i^\sigma > 0, \; c = 1, ..., C. \tag{2}$$

and $P_t^c > 0$ is the domestic price vector for each country, and we assume $\sigma > 1$. Notice that the b_i parameters allow for asymmetric demand (for costs) and supply (for revenue) of the products.

The function (2) cannot be evaluated without knowledge of the parameters b_i. But a standard result from index number theory is that the *ratio* of CES function can be evaluated, using data on price and quantities in the two periods or two countries. Feenstra (1994) shows how this result applies even when the number of goods is changing. In particular, the ratio of the CES aggregator functions over two countries a and b, equals to the product of the Sato-Vartia price index of goods that are common, $I \equiv \left(I_t^a \cap I_t^b\right) \neq \varnothing$, multiplied by terms reflecting the revenue share of "unique" goods:

$$\frac{P_t^a}{P_t^b} = \prod_{i \in I} \left(\frac{p_{it}^a}{p_{it}^b} \right)^{w_i(I)} \left(\frac{\lambda_t^a(I)}{\lambda_t^b(I)} \right)^{1/(1-\sigma)}, \ a, b = 1, ..., C, \tag{3}$$

where the weights $w_i(I)$ are constructed from the revenue shares in the two countries:

$$w_i(I) \equiv \left(\frac{s_{it}^a(I) - s_{it}^b(I)}{\ln s_{it}^a(I) - \ln s_{it}^b(I)} \right) / \sum_{i \in I} \left(\frac{s_{it}^a(I) - s_{it}^b(I)}{\ln s_{it}^a(I) - \ln s_{it}^b(I)} \right) \tag{4}$$

$$s_{it}^c(I) \equiv \frac{p_{it}^c q_{it}^c}{\sum_{i \in I} p_{it}^c q_{it}^c}, \text{ for } c = a, b, \tag{5}$$

$$\lambda_t^c(I) = \frac{\sum_{i \in I} p_{it}^c q_{it}^c}{\sum_{i \in I_t^c} p_{it}^c q_{it}^c} = 1 - \frac{\sum_{i \in I_t^c, i \notin I} p_{it}^c q_{it}^c}{\sum_{i \in I_t^c} p_{it}^c q_{it}^c}, \text{ for } c = a, b. \tag{6}$$

Notice that the output shares in (5), for each country, are measured relative to the *common* set of goods I. Then the weights in (4) are the *logarithmic mean* of the shares $s_{it}^a(I)$ and $s_{it}^b(I)$, and sum to unity over the set of goods $i \in I$.

The first term on the right of (3) is the Sato (1976)-Vartia (1976) price index, which is simply a weighted average of the price ratios, using the values $w_i(I)$ as weights. What is new about equation (3) is the second term on the right, which reflect changes in product variety. If country c in period t has new, unique products (not in the common set I), we will have $\lambda_t^c < 1$. From (3), when $\sigma > 1$ then $\lambda_t^c < 1$ will *lower* the price index of imports, P_t^a/P_t^b. In other words, the introduction of new import varieties will act in the same way as an reduction in prices from that country, provided a welfare gain to consumers.

In practice, we will measure the ratio λ_t^c/λ_t^b using exports of countries to the United States. Specifically, for 1989 – 2001 we use the 10-digit Harmonized System (HS) classification of imports. To measure the ratio λ_t^a/λ_t^b, we need to decide on a consistent "comparison country." For this purpose, we shall use the *worldwide imports* from all countries to the U.S. as the comparison. Denote this comparison country by *, so that the set $I_t^* = \cup_{c=1}^C I_t^c$ is the complete set of varieties imported by the United States in year t. Then comparing country c to country * in year t, it is immediate that the common set of goods exported is $I_t^c \cap I_t^* = I_t^c$, or simply the set of exported by country c. Therefore, from (6) we have that

$\lambda_t^c = 1$, and that:

$$\lambda_t^*\left(I_t^c\right) = \frac{\sum_{i \in I_t^c} p_{it}^* q_{it}^*}{\sum_{i \in I_t^*} p_{it}^* q_{it}^*} = 1 - \frac{\sum_{i \in I_t^*, i \notin I_t^c} p_{it}^* q_{it}^*}{\sum_{i \in I_t^*} p_{it}^* q_{it}^*}. \tag{7}$$

Noting from (3) that product variety in country c relative to the comparison is measured as λ_t^c/λ_t^*, we will instead invert it and obtain a direct measure of import variety from country c relative to the world, as $\lambda_t^*/\lambda_t^c = \lambda_t^*$. The interpretation of λ_t^* in (7) is that it is the *share of worldwide imports into the U.S. from products that are sold by country c*. Equivalently, it is *one minus the share of worldwide imports from products that are not sold by country c*. Note that this measure depends on the set of products sold by country c, I_t^c, but not on its value of imports to the U.S., except insofar as they affect the value of worldwide imports. We use (7) as our measure of import variety from each country c to the United States.

6. EMPIRICAL RESULTS

Gravity Equation

We first estimate a gravity equation for 114 countries selling to the United States, in 1992, with the results shown in Table 1. In columns (1) and (2) we report a conventional gravity equation using the log of imports into the United States as the dependent variable. Explanatory variables in regression (1) are GDP per capita as well as population in each partner country, along with distance to the U.S. (all in natural logs), and these are all significant at the 1% level. In regression (2) we also add several indicator variables: for a common border with the U.S.; OECD member; OPEC member; and having English as the primary language.[13] The OECD and English language indicators are both significant.

In regression (3) and (4) we instead use the log of import variety defined in (6) as the dependent variable. GDP per capita, population in each partner country, and distance to the U.S. continue to be significant, though their coefficient values are somewhat smaller than in regressions (1) and (2). The indicator variables for OECD membership and for

[13] These indicator variables are used by Feenstra, Markusen and Rose (2001), from whom we obtain the distance measures.

English language continue to be significant, too.[14]

We construct the residuals from regressions (3) and (4) to use as explanatory variables in predicting intrafirm trade. These residuals, labeled Variety Residual1 and Variety Residual2 are shown in the Appendix, along with the share of intrafirm trade in total imports from each partner country. Intrafirm trade is the sum of imports shipped by overseas affiliates to their U.S. parents, and import shipped to U.S. affiliates by their foreign parent groups, measured as a percentage of total U.S. imports from that foreign country, as reported by Antràs (2003). Also included in the Appendix is the capital/labor endowment of each country, from Hall and Jones (1999), which is the key explanatory variable used by Antràs (2003). It is clear by inspection that the share of intrafirm trade is positively correlated with the capital/labor ratio, as confirmed in the regressions reported below. The correlation between intrafirm trade and the variety residuals is not as evident, but Taiwan, for example, has a low share of intrafirm trade and an above-average Variety Residual, consistent with our earlier discussion of Taiwan and Korea.

Intrafirm trade regressions

In Tables 2 and 3, we report the same regression as Antràs (2003, Table V), but adding the residual from the gravity equations for variety as an explanatory variable: Table 2 uses Variety Residual1 and Table 3 uses Variety Residual2. It can be seen that these residuals are negatively correlated with the share of intrafirm trade, consistent with our theoretical prediction, and are significant at the 5% level. Regression (1) in each table includes the capital/labor ratio of each country as an explanatory variable, regression (2) adds the labor stock, regression (3) adds the human capital/labor ratio, regression (4) adds the corporate tax rate, and the following regressions add indexes of openness to FDI, to trade, and overall economic freedom. In both tables, the coefficient of the Variety Residual tends to grow in size and significance as more control variables are added.

[14] The indicator variable for common border is also significant, but has an unexpected negative sign. This may be offsetting the larger positive coefficient on the OECD indicator, which might be over-predicting the impact of OECD membership for Canada on export variety sold to the U.S.

Tables 2 and 3 both use the dependent variable from Antràs (2003, Table V), which refers to U.S. intrafirm imports sold to manufacturing industries. That measure of intrafirm trade is most closely matched to the theory presented by Antràs. But our theory seems well suited to include sales to wholesale industries, too. So as an alternative dependent variable, we use intrafirm imports to the U.S. in both manufacturing and wholesale industries, measured as a percentage of total U.S. imports from that foreign country, as reported by Zeile (1997).

The results from this alternative dependent variable are shown in Table 4, where for brevity, we just use Variety Residual2. It can be seen that changing the dependent variable to include sales to wholesale industries reduces the magnitude of the coefficients on both the capital-labor ratio and the variety residual, but the significance of these variables is the same as in Tables 2 and 3. The capital-labor ratio is significant at the 1% level in most cases. The variety residual is significant at the 5% level, and as more controls are added, becomes significant at the 1% level.

As a final specification, we repeat the regressions for 1997, as shown in Table 5. In this case, intrafirm imports to the U.S. include both manufacturing and wholesale industries, as available from Zeile (2003). The variety residual is obtained from a gravity equation run for 1997 (not reported). Besides the variety residual, the other explanatory variables in the Table 5 are identical to those used in Tables 2-4. The significance of the variety residual is not quite as strong in the first regression in Table 5, but it again becomes significant at the 1% level as more controls are added. We conclude that import variety from partner countries is indeed negatively associated with intrafirm trade, as expected from our theory.

7. CONCLUDING REMARKS

This paper has studied a simple model of buyer investment and its effect on the variety and vertical structure of international trade. The model distinguishes between two types of buyer investment: “flexible" and "specific". An analysis of these two types of investment, and of their interactions with the entry and pricing incentives of suppliers, yields two major insights. First, the tension between upstream variety and downstream flexibility can give rise to multiple equilibria in the variety of products traded. While our empirical analysis does not explicitly address the issue of multiple equilibria, the result is consistent with the observation that Taiwan and South Korea, despite the similarities in their underlying economies, have very different structures of export varieties to the U.S. Second, since the potential gains from specific investment is higher with less product variety, and since vertical integration can serve as a mechanism to overcome the hold-up problem under specific investment, less product variety leads to more intrafirm trade. This implication of our theory is supported by the result from our formal empirical analysis.

We have emphasized in this paper the role of buyers in the organization of international trade. One purpose of this approach is to offer an alternative to the existing literature where the focus has been mainly on the role and characteristics of suppliers. This is not to say that considerations of suppliers, particularly of their investment, are not important; but buyer investment could be more relevant under certain situations. For instance, in the context where upstream suppliers compete in setting prices, as in our model, if instead the supplier were making the specific investment, there would be no hold-up problem and no need for vertical integration. This suggests that buyer investment, instead of seller investment, is more likely to be consistent with the negative association between product variety and intrafirm trade.

.......(To be completed.)

Appendix: Country data, 1992

Country	Intrafirm Share	Capital /Labor	Import Variety	Variety Residual1	Variety Residual2
Switzerland	64.1	107.9	21.4	0.66	0.98
Singapore	55.4	56.2	93.9	1.07	0.92
Ireland	53.7	55.7	35.9	0.72	1.16
Canada	45.1	82.4	60.9	0.20	0.42
Netherlands	42.2	79.1	20.8	1.97	2.47
Mexico	41.7	28.4	36.4	2.74	3.34
Panama	35.8	19.8	81.1	0.94	1.08
U.K.	33.2	50.4	37.2	1.77	1.94
Germany	31.9	89.4	19.6	0.63	0.95
Malaysia	30.1	23.5	44.8	1.75	2.69
Belgium	27.3	76.5	85.8	3.01	1.75
Brazil	25.9	21.2	54.8	2.53	2.68
France	21.6	84.9	43.3	4.46	4.36
Sweden	16.8	72.8	48.8	1.76	2.70
Spain	15.5	61.6	44.2	2.24	2.19
Australia	15.5	88.1	55.1	2.37	2.62
Japan	14.2	64.2	59.3	2.87	4.12
Israel	12.4	51.8	58.0	2.71	1.58
Hong Kong	11.2	29.1	82.2	1.64	1.06
Philippines	8.4	8.0	81.8	1.15	0.78
Italy	8.1	82.3	39.7	1.04	0.49
Argentina	5.1	33.2	79.8	5.55	2.90
Colombia	4.6	15.4	58.3	1.29	0.85
Taiwan	4.6	26.2	53.7	2.44	1.38
Venezuela	1.4	42.7	88.9	1.08	0.53
Chile	1.3	22.5	57.1	1.90	1.18
Indonesia	1.3	8.1	60.7	1.54	1.02
Egypt	0.1	3.4	62.7	1.63	0.77
Average	22.4	49.5	21.4	0.66	0.98

Notes:
Intrafirm trade is the sum of imports shipped by overseas affiliates to their U.S. parents, and import shipped to U.S. affiliates by their foreign parent groups, measured as a percentage of total U.S. imports from that foreign country, as reported by Antràs (2003). Capital/labor endowment of each country is for 1988, where the capital stock is measured in $thousands per worker, as reported by Hall and Jones (1999). The import variety measure is constructed as in (6), and Variety Residual 1 and Residual2 are the residuals from the gravity equation in columns (3) and (4) of Table 1.

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Table 1: Gravity equation for U.S. imports, by partner countries (1992)

	Dependent variable: Imports		Dependent variable: Variety	
	(1)	(2)	(3)	(4)
GDP per capita	0.430**	0.345**	0.219**	0.181**
	(6.08)	(5.21)	(7.99)	(7.34)
Population	0.802**	0.778**	0.264**	0.247**
	(8.26)	(7.83)	(6.97)	(6.63)
Distance to U.S.	-1.053**	-1.022*	-0.361*	-0.369*
	(3.03)	(2.49)	(2.55)	(2.24)
Common border		-0.407		-0.599*
		(0.53)		(2.06)
OECD member		1.777**		0.892**
		(4.66)		(5.97)
OPEC member		0.646		0.203
		(0.44)		(0.45)
English language		1.054**		0.349*
		(2.73)		(2.30)
Constant	19.094**	18.747**	2.265	2.383
	(6.74)	(5.89)	(1.89)	(1.78)
Observations	114	114	114	114
R-squared	0.47	0.55	0.51	0.61

Robust t statistics in parentheses
* significant at 5%; ** significant at 1%

Notes:

All variables except indicators are measured in natural logs.

Table 2: Regressions of Intrafirm Trade, by partner countries (1992), First Measure of Import Variety Residual

Dependent variable: Intrafirm imports relative to country imports, Manufacturing industries only						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Ln(K/L)	1.205**	1.176**	1.302*	1.294**	1.072	1.062*
	(0.319)	(0.331)	(0.474)	(0.456)	(0.544)	(0.373)
Ln(L)		-0.119	-0.143	-0.141	-0.111	-0.041
		(0.129)	(0.136)	(0.137)	(0.128)	(0.187)
Ln(H/L)			-0.963	-0.720	-1.312	-0.639
			(1.576)	(1.383)	(1.265)	(1.286)
Corporate tax				-1.085	-0.101	2.302
				(2.962)	(3.433)	(2.512)
Open FDI						-0.484*
						(0.224)
Open Trade						0.299
						(0.275)
Econ freedom					0.356	
					(0.216)	
Variety Residual1	-0.553*	-0.543*	-0.538*	-0.548*	-0.693*	-0.791**
	(0.230)	(0.237)	(0.228)	(0.215)	(0.261)	(0.136)
Constant	-14.531**	-12.316**	-12.476**	-12.270**	-12.443**	-10.593*
	(3.506)	(4.392)	(4.419)	(4.094)	(4.320)	(4.692)
Observations	28	28	28	28	28	26
R-squared	0.53	0.54	0.55	0.55	0.60	0.61

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

Notes:

Variables used are identical to those in Antràs (2003), except for Variety Residual1, which is the residual from the gravity equation in column (3) of Table 1.

Table 3: Regressions of Intrafirm Trade, by partner countries (1992), Second Measure of Import Variety Residual

Dependent variable: Intrafirm import relative to country imports Manufacturing industries only						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Ln(K/L)	1.030*	0.985*	1.163*	1.143*	0.956	0.751*
	(0.384)	(0.403)	(0.513)	(0.477)	(0.563)	(0.295)
Ln(L)		-0.162	-0.200	-0.201	-0.184	-0.182
		(0.131)	(0.130)	(0.130)	(0.129)	(0.180)
Ln(H/L)			-1.440	-1.082	-1.581	-1.222
			(1.539)	(1.405)	(1.371)	(1.291)
Corporate tax				-1.718	-0.969	1.985
				(2.994)	(3.476)	(2.573)
Open FDI						-0.485
						(0.235)
Open Trade						0.232
						(0.291)
Econ freedom					0.270	
					(0.216)	
Variety Residual2	-0.515	-0.546	-0.598*	-0.634*	-0.688*	-1.007**
	(0.322)	(0.324)	(0.281)	(0.244)	(0.289)	(0.197)
Constant	-12.753**	-9.664	-9.725	-9.254	-9.064	-3.984
	(4.233)	(5.270)	(5.151)	(4.517)	(4.795)	(4.093)
Observations	28	28	28	28	28	26
R-squared	0.51	0.53	0.55	0.55	0.58	0.65

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

Notes:

Variables used are identical to those in Antràs (2003), except for Variety Residual2, which is the residual from the gravity equation in column (4) of Table 1.

Table 4: Regressions of Intrafirm Trade, by partner countries (1992), Second Measure of Import Variety Residual

Dependent variable: Intrafirm import relative to country imports, Manufacturing plus Wholesale industries						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Ln(K/L)	0.532**	0.528**	0.515**	0.486**	0.321*	0.611**
	(0.086)	(0.098)	(0.146)	(0.157)	(0.135)	(0.194)
Ln(L)		-0.016	-0.013	-0.014	0.001	-0.089
		(0.092)	(0.103)	(0.102)	(0.088)	(0.093)
Ln(H/L)			0.102	0.655	0.217	0.435
			(0.791)	(0.920)	(0.810)	(0.860)
Corporate tax				-2.653*	-1.996	-3.151
				(1.275)	(1.047)	(1.654)
Open FDI						-0.164
						(0.140)
Open Trade						0.042
						(0.128)
Econ freedom					0.237*	
					(0.094)	
Variety Residual2	-0.346*	-0.349*	-0.345*	-0.401*	-0.448**	-0.488**
	(0.147)	(0.150)	(0.152)	(0.152)	(0.147)	(0.164)
Constant	-6.755**	-6.449**	-6.445**	-5.717*	-5.550*	-4.440
	(0.897)	(2.197)	(2.211)	(2.223)	(2.051)	(2.586)
Observations	28	28	28	28	28	26
R-squared	0.57	0.57	0.57	0.62	0.71	0.67

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

Notes:

The dependent variable differs from that used by Antràs (2003), since it includes sales of foreign companies to their wholesale affiliates in the U.S. Except for Variety Residual2, which is the residual from the gravity equation in column (4) of Table 1, the other explanatory variables are the same as in Antràs (2003).

Table 5: Regressions of Intrafirm Trade, by partner countries (1997), Second Measure of Import Variety Residual

Dependent variable: Intrafirm import relative to country imports, Manufacturing plus Wholesale industries						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Ln(K/L)	0.413**	0.411**	0.468**	0.428**	0.172	0.582*
	(0.093)	(0.092)	(0.126)	(0.110)	(0.090)	(0.233)
Ln(L)		-0.011	-0.023	-0.021	0.008	0.029
		(0.096)	(0.096)	(0.088)	(0.058)	(0.114)
Ln(H/L)			-0.503	0.068	-0.615	-0.010
			(0.848)	(0.854)	(0.551)	(0.843)
Corporate tax				-3.492*	-2.204	-4.044*
				(1.377)	(1.159)	(1.610)
Open FDI						-0.224
						(0.186)
Open Trade						0.206
						(0.179)
Econ freedom					0.389**	
					(0.086)	
Variety Residual2	-0.309	-0.308	-0.345	-0.507**	-0.485**	-0.507*
	(0.165)	(0.171)	(0.188)	(0.170)	(0.143)	(0.198)
Constant	-5.496**	-5.299**	-5.288*	-4.193*	-4.285**	-6.029
	(0.981)	(1.821)	(1.900)	(1.638)	(1.174)	(3.301)
Observations	28	28	28	28	28	26
R-squared	0.57	0.57	0.57	0.62	0.71	0.67

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

Notes:

The dependent variable differs from that used by Antràs (2003), since it includes sales of foreign companies to their wholesale affiliates in the U.S., and is measured in 1997. Except for Variety Residual2, which is the residual from the gravity equation run for 1997, the other explanatory variables are the same as in Antràs (2003).