AN ABSTRACT OF THE THESIS OF

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The integration of the world economy is changing the structure of international transactions. Firms are taking advantage of decreasing market barriers by spreading production across the globe. As foreign production increases, concerns in the United States over the balance of payments and the loss of jobs to foreign countries continue to escalate. The purpose of my thesis is to contribute to this discussion by fitting a theoretical model of a multinational firm to available time series data for several manufacturing industries in the United States. The focus of my thesis is on understanding the determinants of exports and foreign production by U.S. owned firms (through FDI).

Empirical results suggest that an increase in the host country per capita income has a stronger effect on foreign production than exports for the "clean" industries (e.g., food and machinery) while the opposite is true for the "dirty" industries" (e.g., metals and chemicals). I also find that direct investment serve as a means to circumvent trade barriers, suggesting that efforts toward multilateral trade liberalization are likely to improve U.S. welfare.

Determinants of Exports and Foreign Direct Investment in the U.S. Manufacturing Sector

by

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

Determinants of Exports and Foreign Direct Investment in the U.S. Manufacturing Sector

Chapter 1: Introduction

The integration of the world economy is changing the structure of international transactions. Firms are taking advantage of decreasing market barriers by spreading production across the globe. As foreign production increases, concerns in the United States over the balance of payments and the loss of jobs to foreign countries continue to escalate. Neoclassical trade theory lends some support to this claim. For instance, in a Heckscher-Ohlin-Samuelson trade model, differences in fixed (immobile) factor endowments (e.g. capital, land, and labor) explain patterns of trade. Relaxing the factor immobility assumption (mobile capital) lowers differences in factor endowments. Therefore, foreign direct investment (FDI) becomes a substitute for exports as factors such as capital move from the home to the foreign (host) country.

However, a number of studies including Lipsey and Weiss (1981, 1984) find a complementary relationship between exports and FDI by relaxing the assumption of single product firms. That is, FDI could increase exports of intermediate goods to a host country and thereby promote total foreign sales (sum of exports and affiliate sales). Others note that consumer-oriented service facilities available through acquisition FDI would increase the demand for both home and foreign production.[1] Markusen (1983) finds a complementary relationship between FDI and exports by arguing that the substitution between goods and factors is specific to only factor proportion models.

[1] Acquisition FDI is defined as the act of acquiring existing business firm(s) in the foreign country.

Allowing for differences in technologies among countries, Markusen (1983) derives condition under which exports and FDI could be complements.

The purpose of my thesis is to contribute to this discussion by fitting a theoretical model of a multinational firm (MNC) to available time series data for several manufacturing industries in the United States. The focus of my thesis is on understanding the determinants of exports and foreign production by U.S. owned firms (through FDI).[2] Previous empirical investigations have tended to rely either on time series tests or simple regression models relating FDI to prior levels of exports and vice versa (e.g., Pfaffermayr, 1994, 1996). While this approach may identify whether they are substitutes or complements, the lack of a structural framework poses problems in identifying the sources of substitution/complementarity.

For instance, questions such as:

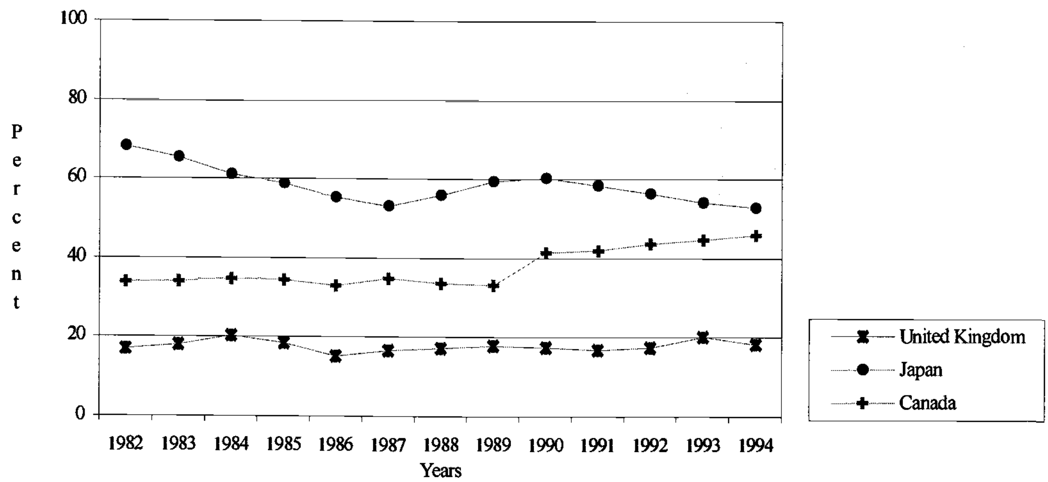
- Does high level of per capita income always indicate more exports relative to FDI or vice versa, (a common belief that FDI occurs within developed countries)? Given that majority of manufacturing output have higher income elasticities, then is it likely that U.S. jobs will be "exported" to the foreign countries if per capita income encourages FDI more than trade?
- Do factor prices provide a "locational advantage?" Is this location-specific advantage enough for the MNC to favor foreign over home production?
- Do protection barriers cause some of the substitution between FDI and exports? If so, will efforts to lower tariffs bring jobs back to the United States?

[2] With approximately 67 percent of the host-country production serving the local market and less than 11 percent of the production exported back to the U.S., affiliate sales acts as a good proxy for a mode by which the MNC serves the foreign country.

are not addressed by most studies on exports and FDI. A careful analysis of the data reveals that the above questions would be insightful in identifying the sources of substitution/complementarity. To better understand forces causing either substitution/complementarity, it is necessary to derive empirical models from conceptual frameworks that allow for such differences and apply them, preferably, to time series data.

The case of the U.S. manufacturing industries indeed provides an interesting setting. Figure 1 shows the share of exports in U.S. foreign sales to three countries in the U.S. manufacturing sector.[3, 4] Variations in both levels and rates of changes in shares suggest that country level factors play a crucial role in the choice to export/produce abroad.[5]

Figure 1: Share of Exports in U.S. Foreign Sales (Manufacturing Sector)



Source: BEA and NBER

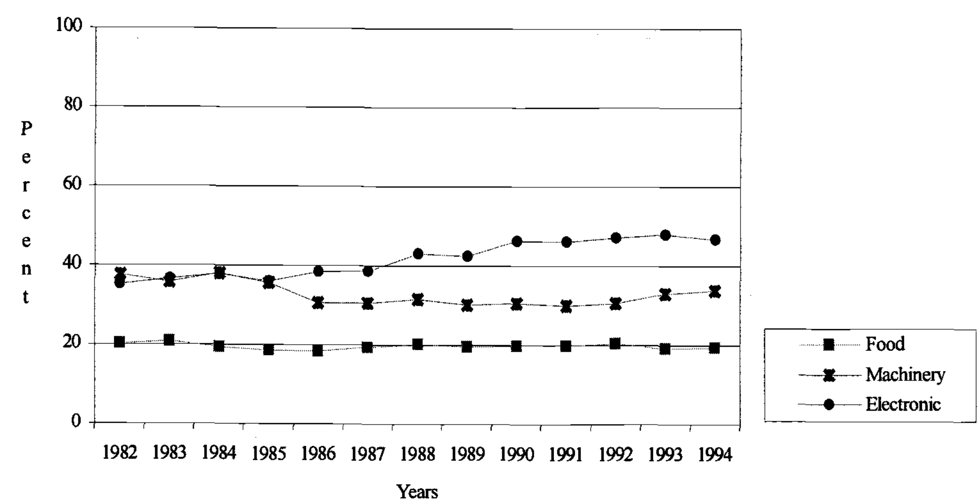
[3] Detailed descriptions of these trends are presented in sections 2 and 4.

[4] Share X_{ei} = (Value of X_{ei})/(Value of X_{ei} + X_{mi}), where i = United Kingdom, Japan, and Canada.

[5] For most of the European countries, the share of exports in U.S. foreign sales is low relative to other countries.

Similar differences are observed at the industry level within the U.S. manufacturing sector. Figure 2 provides the share of exports in U.S. foreign sales for three manufacturing industries; electric and electronic equipment (henceforth called electronic), food, and machinery in the high-income countries.[6, 7] The figure reveals that the share of exports in the food industry is relatively low. In contrast, the share of exports in the electronic industry is high and continues to rise, while that of the machinery industry decreased from 38 percent in 1982 to 30 percent in 1986 before rising to 35 percent in 1994. Thus, the variations found in the data on exports and affiliate sales by U.S. manufacturing firms provide an interesting case study to address the questions I posed earlier.

Figure 2: Share of Exports in U.S. Foreign Sales (High-Income Countries)



Source: BEA and NBER

[6] Share X_{ej} = (Value of X_{ej})/(Value of $X_{ej} + X_{mj}$), where j = Food, Machinery, Electronic.

[7] High-income countries = Canada, France, Germany, Netherlands, United Kingdom, Japan, and Australia.

The remainder of this paper consists of four chapters. Background information on FDI and the U.S. manufacturing sector is available in chapter 2. In chapter 3, I will review previous studies on exports and FDI, in addition to presenting my theoretical and empirical model. A detailed description of my data is available in chapter 4. Finally, I will present my results along with summaries leading to the conclusion in chapter 5.

Chapter 2: Profile of Foreign Direct Investment and the U.S. Manufacturing Sector

2.1 Foreign Direct Investment

According to the U.S. Department of Commerce, foreign direct investment is a 10 or more percent stake of a foreign business enterprise. By their definition, a U.S. resident who undertakes foreign direct investment would be a U.S. parent. They also define a foreign affiliate to be a foreign business in which the U.S. parent has ownership through direct investment. Specifically, Majority-Owned Foreign Affiliates (MOFA) are foreign affiliates of U.S. parents whose combined ownership exceeds 50 percent.

FDI, like other business ventures, has inherent disadvantages. As noted by Markusen *et al.* (1995), foreign affiliates necessitate higher communication (phone calls), transportation (travel expenses for executives) and living (higher wages to induce U.S. personnel to live abroad) costs relative to exports. There may also be additional costs of foreign production, resulting from differences in languages, cultures, technical standards, and customer preferences between the home and host country. They also note that the multinational firm (MNC) may be at a disadvantage, at least initially, due to a lack of familiarity with the host country's business community, tax laws, and other government procedures. There may be regulations in the host country that would prevent the multinational from having full control over all processes of the affiliate production.

Thus, due to the disadvantages of FDI, the MNC will only produce abroad if the firm has some compensating advantages, such as firm-specific assets that can be employed profitably despite the above-mentioned disadvantages (Markusen *et al.*, 1995). There are three conditions, namely ownership-specific, location-specific and internalization (OLI) advantages that are necessary for a firm to undertake FDI in an imperfect market. Proposed by Dunning (1977), OLI represents the motivating force behind the MNC's decision to serve the foreign market through affiliate sales. More specifically, ownership-specific advantages such as trademark, reputation for quality, and a U.S. patent would give the MNC enough valuable market power to outweigh the disadvantages of foreign production (Markusen *et al.*, 1995). By establishing product name through affiliate sales, the MNC may be able to boost total foreign demand.

Similarly, FDI has location-specific benefits like lower factor costs and access to the foreign market. Another locational advantage of direct investment is that it permits the MNC to compete more equally with foreign competition by avoiding trade barriers. However, unlike ownership-specific advantages, location-specific advantages are external to the firm (Dunning, 1977). In particular, all firms producing in the foreign country may benefit from the location-specific advantages.

Internalization advantages consist of transactions such as intra-firm trade that allows the MNC to internally manage its operations rather than at arm's length.[8] By keeping its process or product internal, the MNC may prevent the non-authorized use of its firm-specific asset or technology (also known as the "free-rider" problem). Moreover, unlike portfolio investments, internalization through foreign production provides the MNC with strategic managerial control of the production process (Graham and Krugman, 1995). Thus, in general, FDI increases the MNC's profit by allowing the firm to combine its ownership advantages with the locational advantages of the host country through internalization to increase foreign market share.

[8] Arm's length is defined as indirect or external.

Moving from theory to data, I find that MOFA sales through foreign production accounts for 61 percent of U.S. foreign sales. Column 2 of table 1 displays values of U.S. foreign sales of all goods and services (all industries) to the world from 1982-1994.[9] The share of MOFA sales in U.S. foreign sales is available in column 4. Note that over 50 percent of U.S. foreign sales is from MOFA sales but the share is declining.

Table 1: Values of U.S. Foreign Sales in All Industries to the World ($millions)

Year	U.S. Foreign Sales	MOFA Sales	Share of MOFA sales	Export Sales	Share of Export
1982	1005435	730235	73	275200	27
1983	723048	457048	63	266000	37
1984	746917	456017	61	290900	39
1985	737389	448589	61	288800	39
1986	781475	471775	60	309700	40
1987	888175	539375	61	348800	39
1988	1037612	606312	58	431300	42
1989	1179928	690528	59	489400	41
1990	1346677	809477	60	537200	40
1991	1405771	824471	59	581300	41
1992	1474036	856736	58	617300	42
1993	1480880	837680	57	643200	43
1994	1667579	963779	58	703800	42

Source: BEA

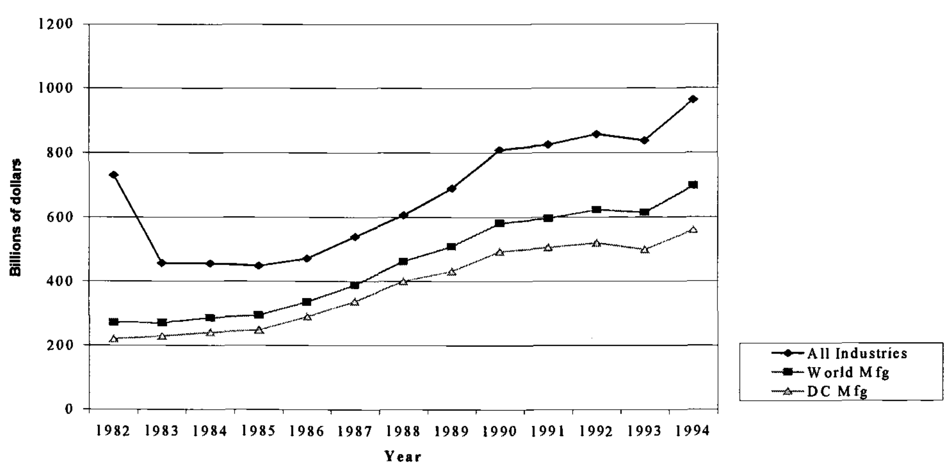
Table 1 also provides values of total U.S. exports in all industries to the world. Column 6 reveals the share of exports in U.S. foreign sales. Though the share of exports

[9] All industries = manufacturing + non-manufacturing industries. World = All countries.

is relatively small in 1982 (at 27 percent), it steadily raises (to 42 percent) and averages to 39 percent during 1982-1994.[10]

As another illustration of direct investment, figure 3 compares MOFA sales in the manufacturing (Mfg) sector to all industries. Manufacturing accounts for 68 percent of sales by foreign affiliates of U.S. multinationals. However, the gap is widening, meaning that more sales by MOFAs are taking place outside the manufacturing sector. In addition, the graph also shows the value of affiliate sales in the manufacturing sector that occurs in the developed countries (DC).[11] It is evident from the graph that the majority of foreign production in the manufacturing sector (an average of 84 percent) is in the developed countries despite lower growth rates after 1990.

Figure 3: MOFA Sales Comparison



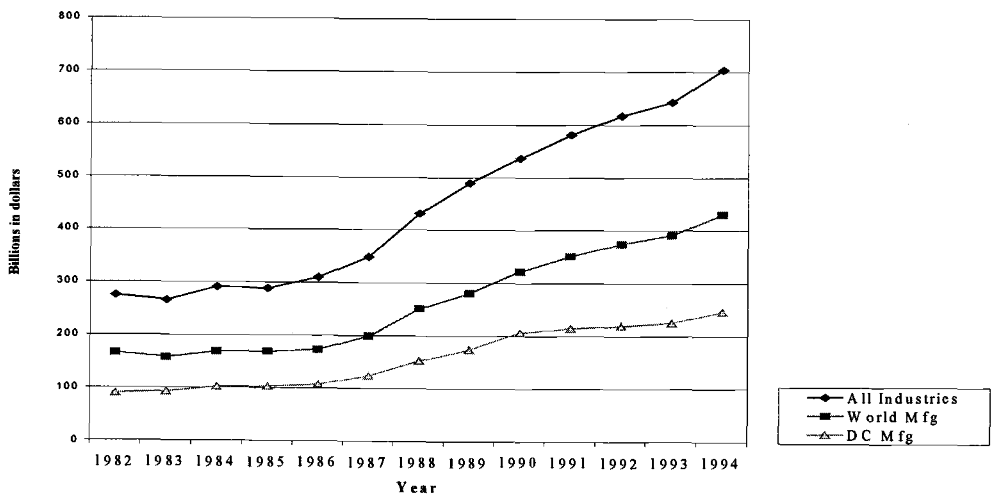
Source: BEA and NBER

[10] The data does not include non-MOFA sales. Moreover, some of the exports are likely to be intra-firm transfer. Hence, the declining (rising) share of MOFA sales (exports) should be interpreted with caution.

[11] See Appendix F for definition of Developed Countries.

Similar to figure 3, another view of exports is available in figure 4. The graph shows a positive relationship between total exports in all industries (to the world) and exports in the manufacturing sector (to the world). More specifically, an average of 59 percent of total exports to the world is from the manufacturing sector. In addition, 60 percent of manufacturing exports is to the developed countries.

Figure 4: Exports Comparison



Source: BEA and NBER

Thus both exports and MOFA sales data reveal significant activities by multinational firms in the manufacturing sector relative to the broader economy. Moreover, the developed countries are an important destination for both exports and MOFA sales. To further illustrate the role of multinational activity in the manufacturing sector, a more in-depth discussion of U.S. foreign sales in the manufacturing sector at the

2-digit Standard Industrial Classification (87SIC) level is presented in the following section.[12]

2.2 The U.S. Manufacturing Sector

As previously mentioned, the manufacturing sector accounts for a large percentage of exports and MOFA sales. The first noticeable feature of table 2 is that U.S. foreign sales increased between 1982-1994. At the aggregate level, sales by foreign affiliates and exports nearly tripled from $310 billions to $806 billions. This means that the aggregate manufacturing sales grew at an average rate of 7 percent a year. At the industry level, there are three manufacturing industries that all but tripled their 1982 foreign sales level. These industries are food, electronic and transportation. With approximate average growth rates of 8 percent, foreign sales in these industries increased faster than the aggregate level. The only industry with average growth rates lower than the aggregate level is the metals industry at 5 percent. Unlike the other industries, U.S. foreign sales in the metals industry only doubled from $19 billions to $37 billions.

[12] Due to the importance of the developed countries and the lack of available data on the developing countries, I will focus only on the former.

Table 2: Total U.S. Foreign Sales in the Developed Countries ($millions)

Year	Mfg	Food	Chemical	Metals	Machinery	Electronic	Transpor-tation
1982	309675	30970	55037	18704	57601	25480	63886
1983	321216	30885	58459	18260	57671	24842	75312
1984	342523	30673	61102	20432	65020	27514	80006
1985	350797	30106	61113	19170	69093	27484	87054
1986	397128	38292	68863	22027	78355	25675	96602
1987	460918	42076	80246	23901	92451	31067	109754
1988	552925	49738	94625	28815	110678	37373	133305
1989	605803	50989	100939	28937	124382	44953	143368
1990	700073	62139	113800	34132	141859	53627	159741
1991	720714	67976	120703	33816	140459	55564	164961
1992	739006	71710	129349	34246	138938	56381	169066
1993	725008	77004	119720	38668	130384	60096	160795
1994	806130	83577	133015	36578	143657	73884	184307

Source: BEA and my own calculation.

Table 3 shows the share of U.S. foreign sales in the manufacturing sector (in the developed countries) that consists of MOFA sales. Compare to the declining share of MOFA sales in all industries (table 1, column 3), the share of MOFA sales in the manufacturing sector is relatively constant. At the industry level, MOFA sales share in chemical is similar to the aggregate manufacturing level in that it is relatively unchanged. The three industries that exhibit a decline in the share of MOFA sales are metals, electronic and transportation. However, these declines are relatively small compare to the decreasing share of MOFA sales in all industries. In contrast to the other industries, there is an increase (although small) in the MOFA sales share in the food and machinery industry.

Table 3: Share of MOFA Sales in U.S. Foreign Sales to DC ($millions)

Year	Mfg	Food	Chemical	Metals	Machinery	Electronic	Transportation
1982	71	80	80	64	63	68	77
1983	71	80	80	63	65	66	75
1984	70	82	79	62	63	65	75
1985	71	83	79	64	65	67	72
1986	73	83	81	68	70	62	73
1987	73	83	81	68	70	62	74
1988	72	82	81	64	69	59	74
1989	72	86	82	66	73	63	73
1990	71	86	83	63	73	59	71
1991	70	86	82	62	72	59	70
1992	71	85	83	63	72	58	71
1993	69	85	81	53	69	58	71
1994	70	85	81	61	68	59	71

Source: BEA and my own calculation.

Chapter 3: Theoretical Issues

3.1 Literature Review

Through Ricardo, the importance of trade in increasing the home country's welfare is well understood. In contrast, there are many misconceptions as to who gains or loses as a result of direct investment. There are union members and public officials who fear that foreign production not only exports "good" jobs from the U.S., but also depletes the nation of valuable resources. Although my research is not on welfare economics, a careful examination of the determinants of trade and FDI may clear up some misunderstandings.

The determinants of exports and FDI have been addressed by a number of authors both conceptually and empirically [Helpman (1987), Lipsey and Weiss (1981), Markusen (1996)]. A predominant number of these studies use a vertical-integration approach to examine the role of exports and direct investment [Helpman and Krugman (1985), Helpman (1981, 1987)]. According to this theory, the MNC integrates production vertically across borders to exploit factor price differences associated with unequal relative factor endowments. Through factor-price equalization countries export the services of factors in which they are abundantly endowed (Krugman, 1985).

Another view of the relationship of exports and FDI is the horizontal-integration approach where countries are relatively similar in size and factor endowments (Markusen, 1996, 1997). By relaxing certain assumptions in the Heckscher-Ohlin model such as perfect competition, no domestic market distortions, and identical technologies between trading countries, Markusen (1983) demonstrates that trade results from something other than differences in factor proportion. Starting with equal endowments, capital (labor) moves toward the trading partner that is more productive in utilizing it and thereby making that country well endowed with capital (labor).

In addition, several authors focus on distance instead of factor endowments as the basis for trade. Assuming a market structure with differentiated products, Brainard (1997) uses the proximity-concentration hypothesis to suggest that firms expand foreign production in response to higher transport costs and trade barriers. Similarly, Graham (1995) uses a gravity model to estimate the effects of host country per capita income, market size and distance to determine the relationship between FDI and exports. Using distance as a crude proxy for transport and other costs such as communication, Lipsey and Weiss (1981) find that distance is insignificant in explaining exports. Interestingly, the findings of all three studies support Markusen (1983) in that trade and FDI are complements.

My analysis builds on previous efforts in four important ways.

- First, my study assumes an imperfectly competitive model where the multinational is a Chamberlinian monopolist [Brainard (1997), Branstetter and Feenstra (1999), Helpman (1981), Helpman and Krugman (1985)]. Such a model is more characteristic of multinational activity in the real world where the firms compete for shares in the foreign market.
- Second, in my examination of the key factors determining export/foreign production, I will follow Gopinath *et al.* (1999) by accounting for the effects of income level and factor prices. Building on Graham (1995), Gopinath *et al.* note that previous

investigations ignore the possible effects of simultaneous determination of FDI and exports.

- Third, I will follow Brainard (1997) by including trade barriers in my model. Few studies incorporate trade barriers despite claims of its value as an explanatory variable [Gopinath *et al.* (1999), Lipsey and Weiss (1984)]. Although an accurate measure of trade restriction is currently unavailable, omission of all proxies for trade barriers would understate the importance of FDI as a means to serve the foreign market. Through FDI, the MNC is able to jump over barriers set by the host country to discourage trade.
- Fourth, I will account for the effects of exchange rates on exports and affiliate sales. Several studies including Froot and Stein (1991) note the connection between exchange rates and FDI that arise from imperfect information in the global capital markets. Their theory is based on the possibility that the MNC's borrowing opportunities for FDI is positively related to an appreciation of the home country currency relative to the host country. In addition, fluctuations in the exchange rates also effect home country exports. A depreciation (appreciation) of the U.S. dollar would encourage (discourage) exports since U.S. products would be less (more) expensive relative to goods dominated in the foreign currency.

3.2 Theoretical Model

The focus of my paper is on a representative multinational firm's decision-making process characterized by the Chamberlinian monopolistic competition. Assuming a

Dixit-Stiglitz (1977) type preference for differentiated products, I will derive the consumer demand function from a utility maximization problem.[13] Given the consumer demand equations, I will solve for the firm's profit maximizing strategies.

3.2.1 The Consumer

The Dixit-Stiglitz (DS) or 'love of variety' approach assumes a separable utility function with convex indifference curves. This two-level utility function can be represented by,

$$U = U[u_1(\cdot), u_2(\cdot), \ldots, u_I(\cdot)] \quad (1)$$

where u_i is a symmetric subutility function derived from product consumption. The upper tier utility function, $U(\cdot)$ is the consumer welfare from the aggregate of the intersector subutility levels (Helpman and Krugman, 1985).

One of the main distinguishing features of the DS-type preference is the assumption that an individual prefers to consume many varieties of certain commodities provided the price of each variety is relatively the same. In addition, Helpman and Krugman (1985) remark that in the limiting case where the prices of all varieties of the product are the same, an individual would consume all available varieties in equal proportion. Note that the theoretical outcome would remain the same whether I assume

[13] For the purpose of this paper, the results would remain unchanged whether I use the Dixit-Stiglitz (1977) or the Lancaster (1979) approach. According to Krugman (1985), the main point is to have an equilibrium in the number of differentiated products produced by firms that possess monopoly power but do not earn monopoly profits.

that each individual prefers a different variety or that there exist a taste for variety within the population (Helpman and Krugman, 1985).

To begin with, I assume that the MNC produces different varieties from its foreign competitors (host country and other non-U.S. firms) and that every variety is demanded in the host country. Drawing from Branstetter and Feenstra (1999) (henceforth called B-F), I will determine the MNC's foreign market share and profit maximizing strategies. Specifically, I assume that each country produces a numeraire good (X_0) and a differentiated product (X). The country's production of the X_0 is normalized at unity while the differentiated product is defined by a constant elasticity of substitution (CES) function of the various varieties. Suppose also that the different varieties of the differentiated product are good substitutes among themselves, but are poor substitutes for the numeraire good (Dixit and Stiglitz, 1977).

The foreign consumer has three sources from which to choose the varieties of product X. These sources are the foreign varieties (n_f), and the U.S. varieties (n_e), where m of these are produced by the MOFA and the remaining ($n_e - m$) are imported into the host country. Note that I assume the foreign varieties (n_f) to include outputs from the host country and other non-U.S. producers. Given such consumption choices, the consumer preference can be represented by

$$(2) \qquad U = Xo + \left(\frac{\theta}{\theta - 1}\right) X^{(\theta - 1)/\theta} \qquad \theta > 0\,, \theta \neq 1$$

where the CES aggregate is

$$(3) \qquad X = \left[n_f X_f^{(\varepsilon-1)/\varepsilon} + (n_e - m)X_e^{(\varepsilon-1)/\varepsilon} + mX_m^{(\varepsilon-1)/\varepsilon} \right]^{\varepsilon/(\varepsilon-1)}, \quad \varepsilon > 1$$

The parameter θ measures the elasticity of demand for the CES aggregate while ε captures the own-price elasticity of demand for each variety.[14] B-F also assumes that the cross-price elasticity for each variety is positive by restricting $\varepsilon > \theta$. The consumption of each varieties is denoted by X_j where j = f, e, m. To simplify the model, I make the usual assumptions that U(·) is increasing and homothetic in its arguments.

The foreign consumer's decision problem is to maximize the utility given in equation (2) subject to the following budget constraint:

$$(4) \qquad E = X_o + n_f P_f X_f + (n_e - m)P_e X_e + mP_m X_m$$

where E stands for aggregate expenditure in terms of the numeraire.[15] The demand equation from utility maximization is

$$(5) \qquad X_j = P_j^{-\varepsilon} q^{\varepsilon-\theta} \quad , j = f, e, m \quad X = q^{-\theta}$$

[14] Note that ε has to be greater than one or the multinational's marginal revenue in this monopolistic competition would be negative.

[15] Prices $P_m \neq P_e \neq P_f$ but for all varieties within each category j (=f, e, m) the prices are equal.

where q is a price index,

$$(6) \qquad q = \left[n_f P_f^{(1-\varepsilon)} + (n_e - m) P_e^{(1-\varepsilon)} + m P_m^{(1-\varepsilon)} \right]^{1/(1-\varepsilon)}$$

and P_j represents the prices of each good. See Appendix A for derivation of the demand functions.[16] Equation 5 and 6 assumes that prices across varieties may by different but are the same for core attributes within the varieties. Moreover, the assumption of homothetic preferences implies that the share of spending allocated to product X depends only on the number of varieties and prices available to the foreign consumer (Helpman and Krugman, 1985).

3.2.2 The U.S. Multinational Firm

Moving to the supply side of the story, I assume that the MNC decides to serve the foreign market through domestic production (which is exported) and foreign production. The unit cost of production is

$$(7.1) \qquad C_e = C_e(w_e, r_e)$$

$$(7.2) \qquad C_m = C_m(w_f, r_f)$$

[16] See Appendix B for derivation of the U.S. market share under homogenous goods

where w_j and r_j are the factor prices of labor and capital, respectively, in the U.S. (j = e) and the host country (j = f).[17, 18] Note that although my focus is on j = e and m, I use factor prices in the host country (j = f) for affiliate productions. In addition, note that aside from differences in factor prices, the marginal cost of producing at home may differ from producing abroad, depending on the level of the host country trade barriers (τ). Taking the foreign varieties and prices as given, the MNC's problem is

$$\Pi^* = \max(\Pi_e + \Pi_m)\delta \tag{8}$$

where

$$\Pi_e = (n_e - m)[P_e - (C_e + \tau)]X_e \tag{8.1}$$

$$\Pi_m = m(P_m - C_m)X_m \tag{8.2}$$

The bilateral exchange rates (δ) in units of the home to the host country's currency is included since profits are ultimately converted back to the U.S. dollar. By utilizing the demand equations in (5) and equating marginal revenue with marginal cost, the profit maximizing prices are:

$$P_e = \left[\frac{\varepsilon}{\varepsilon - 1}\right](C_e + \tau) \tag{9.1}$$

$$P_m = \left[\frac{\varepsilon}{\varepsilon - 1}\right]C_m . \tag{9.2}$$

[17] See Appendix C for derivation of the profit equations.

[18] I assume that the firm has constant returns to scale.

By substituting these prices into (8), B-F obtain the MNC's profit strategies from producing at home and abroad:

(10.1) $$\Pi_e = (n_e - m)P_eX_e/\varepsilon$$

(10.2) $$\Pi_m = mP_mX_m/\varepsilon\ .$$

With the objective function in equation (8), the MNC must decide where to produce. In choosing a location, the firm takes into consideration the fixed cost ($F > 0$) that is associated with producing abroad. As a result, the MNC will supply to the foreign market through MOFA sales only if $\Pi_m - F \geq \Pi_e$. Substituting for the profit equations in (10) gives,

(11) $$\frac{mP_mX_m}{\varepsilon} - F \geq \frac{(n_e - m)P_eX_e}{\varepsilon}\ .$$

Equation (11) shows that the MNC would serve the foreign market through exports and MOFA sales if the profits from the former are at least equal to the latter. In order for the firm to strictly prefer a particular mode of servicing the foreign market to another, the profits from producing in one location must be greater. For example, the MNC would produce exclusively at home if it could capture higher profits from exports relative to MOFA sales. Export profits would be greater than affiliate sales if the conditions influencing home production are favorable.

3.3 Empirical Model

Consider the following reduced form of the MNC' s profit function (10)

(12) $$\Pi = \Pi(P_e, P_m, m, \varepsilon, \delta)$$

or

(13) $$\Pi = \Pi(C_e, C_m, m, \varepsilon, \delta, \tau).$$

by substituting for prices from equation (9). The level of exports can be inferred from the derivative of the profit function with respect to export prices,

(14.1) $$\frac{d\,\Pi}{d\,P_e} = \frac{(n_e - m)X_e}{\varepsilon} \; .$$

Similarly, the optimal level of affiliate sales is

(14.2) $$\frac{d\,\Pi}{d\,P_m} = \frac{mX_m}{\varepsilon} \; .$$

Since factor prices can represent the cost of production (domestic and foreign), equations (14) can be written as (ignoring ε, the own-price elasticity of demand),

(15.1) $$X_e^* = f(w^e, w^f, r^e, r^f, m, \delta, \tau)$$

(15.2) $$X_m^* = f(w^e, w^f, r^e, r^f, m, \delta, \tau).$$

where X_e^* and X_m^* denote total exports and MOFA sales, respectively. Equation (15) translates to the MNC taking into consideration the relative factor prices at home and abroad, the exchange rates, the number of varieties, and the host country's openness to trade in its decision to export/produce abroad.

In this paper, I use firm-level theory to hypothesize the MNC's locational decision. However the empirical model consists of estimable equations at the industry level, as firm-level data are not available. To account for this difference, I will analyze the industry exports and affiliate sales as the sum of foreign-sales decisions made by all representative firms in my monopolistic competitive framework (Ray, 1989). More formally, I assume that the industry behavior is the sum of decisions made by individually and independently acting MNC.

It is worth noting that while most of the previous efforts recognize the difference between FDI and portfolio investments such as bonds, their empirical models specify equations for exports in final output and FDI (an input) as a surrogate for affiliates output (Graham, 1995). For example, Pain and Wakelin (1998) examine the role of inward and outward investment and exports using the stock of FDI as a proxy for the level of foreign-owned operations.[19] In another study, Wheeler and Mody (1992) utilize foreign capital expenditures to determine the firm's decision to invest abroad. Likewise, Blecker and Feinberg (1995) analyze the U.S. international performance with values of direct investment position abroad (measured at historical costs).

[19] Stock FDI is defined as the sum of the foreign affiliates' equity (including retained earnings), plus the sum of net lending to these affiliates from the MNC (Graham and Krugman, 1995).
Inward investment is defined as inbound foreign direct investment.
Outward investment is defined as foreign direct investment abroad.

In addition to the problem of inconsistent comparison, many studies are criticized for using cross-sectional data to examine the role of FDI and exports (Lipsey and Weiss, 1981, 1984). According to Pain and Wakelin (1998), an investigation of the levels of FDI and exports in an isolated year would bias the results since both activities parallel the general economic growth in the world economy. Thus, they note the importance of pooling time series and cross-sectional (panel) data to capture the changes in the relationship between outward investment and export performance over time. One of the benefits of a panel data is that it allows researchers to address questions that cannot be examined with a cross-sectional data alone (Greene, 1997).

Moreover, only a small number of studies use 2-digit SIC data. Most studies concentrate on the manufacturing sector as a whole. Only a few studies use aggregate manufacturing data, in addition to a more narrow focus such as the pharmaceutical industry, in studies of direct investment and exports (Lipsey and Weiss, 1984).

My estimable equations to follow differ from the previous analysis in a number of ways. Most importantly, I will use Majority-Owned Foreign Affiliate (MOFA) sales as a proxy for foreign production. Only a small number of studies aside from Lipsey and Weiss (1981, 1984) employ this data to measure the MNC's production in the host country.

In addition, I will make use of available data on total exports, rather than the exports by parents, to account for any displacement of the MNC's exports to the host country by another U.S. firm's affiliate production (Lipsey, 1994). Moreover, my data includes six industries at the 2-digit 87SIC level as well as manufacturing at the aggregate level.

Also important is the use of a panel data that consists of seven countries and thirteen years to estimate my empirical model.[20] The few studies that use panel data for empirical analysis are Pain and Wakelin (1998) and Gopinath *et al.* (1999).

To test the theory outlined in my theoretical section, I will use two estimable equations. In the following empirical counterparts of equation (15), I include a subscript for the industry (i) and time (t) but omit the ones for country (j), for clarity.

$$(16.1) \qquad LogX_{ei} = \alpha_0 + \alpha_1 Log(X_{ei(t-2)}) + \alpha_2 Log(w_e/w_f) + \alpha_3 Log(r_e/r_f) + \alpha_4 Log(GNPpc_f) + \alpha_5 Log(\delta) + \alpha_6 Log(\tau_f) + \alpha_7 Log(Con_{fi}) + u_1$$

$$(16.2) \qquad LogX_{mi} = \beta_0 + \beta_1 Log(X_{mi(t-2)}) + \beta_2 Log(w_e/w_f) + \beta_3 Log(r_e/r_f) + \beta_4 Log(GNPpc_f) + \beta_5 Log(\delta) + \beta_6 Log(\tau_f) + \beta_7 Log(Con_{fi}) + u_2$$

where w_j and r_j are the factor prices in j (= e for U.S., and f for the host country), GNPpc serves as a surrogate for the host country's market size, δ is the bilateral exchange rates, τ measures the extent to which the host country is open to trade and Con is a proxy for product differentiation. I include the lagged dependent variable to allow for non-instantaneous adjustments.[21] The error term (u_i) is used to capture effects that are not explained by the independent variables.

The two equations in (16) will be analyzed using the SAS time series cross section regression (TSCREG) procedure. Since data on transportation costs are not

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[20] See appendix D for a description of panel data.

[21] The second-period lag serves as an instrument for the first-period lag. The proof is available in appendix E.

available on a time-series basis, I will account for the country-specific effects with country dummy variables. In addition, I expect contemporaneous correlation between the cross-sectional units (countries) as several are members of the European Union. There may be serial correlation as the process of investing and exporting is not necessarily instantaneous (Gopinath *et al.*, 1999). I also anticipate heteroskedasticity since the level of exports and FDI are different across the countries. To account for the contemporaneous correlation between cross-sections, serial correlation, and heteroskedasticity, I will use the Parks method, which specifies errors as:

$$u_{it} = \rho u_{i,t-1} + e_{it}, \qquad (17)$$

This model assumes a first-order autoregressive error structure with contemporaneous correlation between cross sections. Moreover, I will include country dummy variables to account for the non-random country-specific effects.

3.4 Hypothesis

Since many studies claim that increasing U.S. labor costs are causing the multinational firms to favor foreign over home production, I expect to find a positive (negative) relationship between relative labor costs and MOFA sales (exports). However, labor costs may have an insignificant affect on either foreign or home production since my study consists of only high-income countries (Wheeler and Mody, 1992).

The results on the capital rental costs should be similar to those on the labor costs. Specifically, an increase in the U.S. capital rental rates relative to the host country should promote MOFA sales over exports. Such results would coincide with Barrell and Pain's (1996) finding of a positive relationship between relative capital costs and outward direct investment.

My proxy for measuring the foreign market size, GNP per capita in U.S. dollars, should be positively related to both exports and MOFA sales. Evidence from earlier studies demonstrates the significance of the host country's market size in the level of direct investment [Barrell and Pain, (1996), Kravis and Lipsey, (1982)].

I include real exchange rates to capture the effects of broader economic policies on both exports and direct investment (Gopinath *et al.*, 1999). Cushman (1985) notes that uncertainty about the price levels and exchange rates may have an impact on long-term investments. The exchange rate variable is lagged by one-period to allow for non-instantaneous adjustments. Several studies suggest that without perfect capital mobility, exchange rates may affect the MNC's investment decision (Cushman, 1983, 1985). Unlike passive investment portfolio of stocks and bonds, direct investments could influence the MNC's relative cost of capital due to information asymmetries (Froot and Stein, 1991). By looking beyond the traditional assumption that FDI are similar to bonds, Blonigen (1997) finds that there is an unambiguous relationship between exchange rates and direct investment. From the supply-side of the theoretical model, I expect MOFA sales to decrease with a depreciation of the dollar since changes in the exchange rates would impact the wealth of the multinational firm. In contrast, the demand-side of the theoretical model states that a weaker dollar should increase exports since commodities in

U.S. dollars would be more competitive relative to goods dominated in the foreign currency.

To more accurately estimate the MNC's decision to export/produce abroad, a measurement of the host country's protectionist polices is necessary since trade barriers discourage exports. Nevertheless, barriers to trade are ambiguous. Aside from tariffs, there are many other forms of restrictions such as non-tariff barriers and voluntary export restraints which make any precise calculation difficult, if not impossible (Barrell and Pain, 1996). With this constraint in mind, I use openness to trade (total imports/GDP) as a proxy for the host country's exposure to external competition. Previous studies suggest that MOFA sales should increase with a closed market since limitations on imports would enhance profits from foreign production (Wheeler and Mody, 1992). However, an increase in the host country's openness to trade may also enhance affiliate sales since foreign productions utilize intermediate goods that are exported from the home country.

Similar to the openness to trade, an increase in the host country's industry concentration may encourage both exports and MOFA sales. With a DS-type preference, the addition of varieties in the foreign market leads to an increase in the foreign consumer's demand. Several studies point out that direct investment occurs extensively with differentiated outputs since investors have the opportunity to capture rents based on this product differentiation (Baldwin, 1979). However, Baldwin also finds that statistically, trade is not closely related to product differentiation. This is possible, as some goods require host country attributes, in addition to firm-specific technology to meet the demand for differentiated products. More specifically, attributes such as customer-oriented support facilities, available through foreign production may be required to increase foreign demand as such programs provide evidence of the MNC's permanent commitment to the host country [Barrell and Pain (1996), Lipsey and Weiss (1984)].

Chapter 4: Data

My study used data from several sources. The first main source is the Bureau of Economic Analysis (BEA), U.S. Department of Commerce. Through various publications by the BEA, I obtained information on MOFA sales. The second main source is the export data from the National Bureau of Economic Research (NBER). In addition to these two sources of data, I also used various publications and databases available through the United Nations (UN), World Bank, International Monetary Fund (IMF) and the Bureau of Labor Statistics (BLS), U.S. Department of Labor. The remainder of this section consists of a more detailed discussion of the data.

4.1 MOFA Sales Data

Each year the BEA conducts mandatory surveys covering all U.S. direct investment abroad. Among other data these annual surveys contain information relating to the activities of the MOFAs. The BEA provide data on MOFA sales according to the international surveys industry (ISI) classifications with corresponding 3-digit 1987 Standard Industrial Classification (87SIC) codes.[22] However, prior to 1989, disaggregate data on MOFA sales in the European countries are unavailable at the 3-digit 87SIC level. Therefore, my analyses used MOFA sales at the 2-digit 87SIC level to maintain consistency throughout the thirteen-year study period.

[22] See appendix G for a detailed list of SIC codes.

According to the International Investment and Trade in Services Survey Act, the BEA must keep the survey data confidential, which causes some data to be "missing." Due to the paucity of data, my study consists of seven developed countries: Canada, France, Germany, Netherlands, United Kingdom, Japan and Australia. There are some data issues even within these countries. Out of the total MOFA sales data, about 8 percent of the observations are missing due to two problematic countries, Japan and Australia. My main method of estimating the missing values is to use regression on the available data within the manufacturing sector.[23] In addition to the regression, I also used the published data on sales by non-majority affiliates to calculate the missing values of the majority-owned affiliates. Since the ratio of sales by MOFA to all non-majority affiliates are fairly consistent, this method proved very valuable.

4.2 Export Data

The NBER U.S. export data is from Robert C. Feenstra. The data is available at the 4-digit 87SIC level for all U.S. trading partners from 1972-1994. To correspond with the MOFA sales data, I summed the disaggregated export values for the seven countries to the 2-digit 87SIC level.

[23] For each country with data limitation, I regressed the industry with missing values (food) on the industries with complete data.

4.3 Wage Rates

The ratio of the U.S. to the foreign country's wage rates utilizes data from the BLS publication on wage compensation for the production workers in manufacturing. The BLS defines hourly compensation as (1) hourly direct pay and (2) employer social insurance expenditures and other labor taxes.

Table 4 displays the hourly wage compensation for the high-income countries plus the home country in U.S. dollars. From 1982 – 1994 there is a general increase in the hourly wage in all the countries. The most significant increase is in Japan with average growth rates of 10 percent followed by Germany at 7 percent. The hourly wages changed the least in Australia with average growth rates of 2 percent. In 1994, the cost of labor is most expensive in Germany at $27 per hour. However for the same year, the average hourly wage rates of the four EU countries ($20) is less than that of Japan ($21).

Table 4: Wage Rates for the Production Workers in Manufacturing (U.S. Dollars)

Year	United States	Canada	France	Germany	Netherlands	United Kingdom	Japan	Australia
1982	11.68	10.44	7.85	10.28	9.78	6.92	5.60	9.98
1983	12.14	11.13	7.74	10.19	9.49	6.49	6.03	9.31
1984	12.55	11.14	7.29	9.37	8.70	6.04	6.23	9.83
1985	13.01	10.94	7.52	9.53	8.75	6.27	6.34	8.20
1986	13.26	11.10	10.28	13.34	12.22	7.66	9.22	8.54
1987	13.52	12.04	12.29	16.91	15.14	9.09	10.79	9.46
1988	13.91	13.50	12.95	18.16	15.83	10.61	12.63	11.35
1989	14.32	14.77	12.65	17.66	15.00	10.56	12.53	12.41
1990	14.91	15.84	15.49	21.88	18.06	12.70	12.80	13.07
1991	15.58	17.16	15.65	22.63	18.13	13.74	14.67	13.53
1992	16.09	17.03	17.46	25.38	20.10	14.37	16.38	13.02
1993	16.51	16.43	16.79	25.32	20.08	12.41	19.21	12.49
1994	16.87	15.85	17.63	27.03	20.80	12.80	21.35	14.02

4.4 Capital Rental Rates

Following Gopinath *et al.*, (1999), I used the normal lending rates as a proxy for the user cost of capital. The IMF publishes these rates in the International Financial Statistics Yearbook (IFS). According to the IMF, lending rates are interest rates that meet the short- and medium-term financing needs of the private sector.

Unlike the increasing trends of the wage rates, there are great fluctuations in the capital rental rates. For most of the countries, the user cost of capital decreased between 1982 – 1987 and then again between 1990 – 1994. The average capital rental rates for all the countries, except Japan and Australia, in the thirteen-year period is approximately 10 percent. The average capital rental rates for Japan and Australia are 6 and 16 percent respectively. Thus, while Japan has the fastest growing wage rates, it has the lowest capital rental rates. In contrast, Australia on average has the highest user cost of capital.

Table 5: Capital Rental Rates

Year	United States	Canada	France	Germany	Netherlands	United Kingdom	Japan	Australia
1982	14.86	15.81	13.63	13.50	11.17	11.84	7.31	14.55
1983	10.79	11.17	12.25	10.05	8.46	9.85	7.13	14.04
1984	12.04	12.06	12.15	9.82	8.88	9.75	6.75	14.46
1985	9.93	10.58	11.13	9.53	9.25	12.33	6.60	15.96
1986	8.35	10.52	9.94	8.75	8.63	10.83	6.02	19.85
1987	8.21	9.52	9.60	8.36	8.15	9.64	5.21	19.83
1988	9.32	10.83	9.43	8.33	7.77	10.29	5.03	18.52
1989	10.92	13.33	10.00	9.94	10.75	13.92	5.29	21.71
1990	10.01	14.06	10.49	11.59	11.75	14.75	6.95	20.48
1991	8.46	9.94	10.22	12.46	12.40	11.54	7.53	14.28
1992	6.25	7.48	10.00	13.59	12.75	9.42	6.15	11.06
1993	6.00	5.94	8.90	12.85	10.40	5.92	4.41	9.72
1994	7.14	6.88	7.89	11.48	8.29	5.48	4.13	9.55

4.5 Income per Capita

My measurement for income per capita is the host country's GNP per capita in U.S. dollars. These values are taken from the World Bank World Development Reports. To avoid multicollinearity, I will include neither GNP nor population as an indicator of the host country's market size. Instead, I assume that per capita income serves a proxy for market size since the average correlation between GNP per capita and population is well over 93 percent.

The trend of the GNP per capita is similar to the hourly wage compensation in that both increased between 1982-1994. The fastest growing market is Japan at an average of 10 percent. The average growth rates of the EU countries are at a distance second at approximately 5 percent. Canada and Australia come in last with rates of approximately 4 percent.

Table 6: Income per Capita (U.S. Dollars)

Year	Canada	France	Germany	Netherlands	United Kingdom	Japan	Australia
1982	11320	11680	12460	10930	9660	10080	11140
1983	12310	10500	11430	9890	9200	10120	11490
1984	13280	9760	11130	11130	8570	10630	11740
1985	13680	9540	10940	9290	8460	11300	10830
1986	14120	10720	12080	10020	8870	12840	11920
1987	15160	12790	14400	11860	10420	15760	11100
1988	16960	16090	18480	14520	12810	21020	12340
1989	19030	17820	20440	15920	14610	23810	14360
1990	20470	19490	22320	17320	16100	25430	17000
1991	20440	20380	23650	18780	16550	26930	17050
1992	20710	22260	23030	20480	17790	28190	17260
1993	19970	22490	23560	20950	18060	31490	17500
1994	19510	23420	25580	22010	18340	34630	18000

4.6 Real Exchange Rates

I obtained the bilateral real exchange rates from a calculation done by Andy Jerardo originally from the Federal Reserve Bank at St. Louis. The rates are in units of U.S. dollar per national currency. The exchange rates in table 7 suggest that the Japanese yen appreciated the highest against the U.S. dollar relative to the other currencies between 1982-1994. The currencies of three EU countries (France, Germany and Netherlands) also appreciated relative to the U.S. dollar. In the same period the Australian and Canadian dollar, in addition to the British pound decreased in value relative to the U.S. dollar.

Table 7: Real Exchange Rates (U.S. Dollar per National Currency)

Year	Canada	France	Germany	Netherlands	United Kingdom	Japan	Australia
1981	0.757	0.163	0.522	0.483	1.713	0.006	0.830
1982	0.768	0.142	0.482	0.451	1.523	0.005	0.768
1983	0.789	0.130	0.459	0.420	1.339	0.005	0.727
1984	0.751	0.117	0.404	0.370	1.183	0.005	0.706
1985	0.715	0.116	0.386	0.353	1.168	0.005	0.579
1986	0.718	0.152	0.513	0.470	1.355	0.007	0.594
1987	0.758	0.174	0.599	0.544	1.518	0.007	0.650
1988	0.816	0.173	0.596	0.540	1.665	0.008	0.748
1989	0.850	0.160	0.546	0.485	1.575	0.007	0.777
1990	0.857	0.184	0.619	0.549	1.774	0.007	0.780
1991	0.884	0.176	0.598	0.529	1.791	0.007	0.771
1992	0.826	0.186	0.642	0.564	1.794	0.008	0.713
1993	0.765	0.172	0.613	0.532	1.513	0.009	0.653
1994	0.706	0.174	0.627	0.544	1.542	0.009	0.697

4.7 Openness to Trade

As a simple measure for barriers to trade, I used the foreign country's imports (of all goods and services) from all countries divided by its gross domestic product (GDP). Both values are published in the IFS in national currency. I omitted the host country's exports in the numeraire to prevent endogeneity. This omission should not bias my results since other findings show that the results of the share of imports in GDP is almost identical to those using total trade (exports plus imports) or export share (Levine and Renelt, 1992).

Table 8 indicates that Netherlands is most opened to trade. Although the average level of trade restriction in Canada and Germany are approximately the same in the thirteen-year period, the former differs from the latter in that it is becoming less restrictive. Out of the seven countries, Japan is the most restrictive followed by Australia.

Table 8: Openness to Trade

Year	Canada	France	Germany	Netherlands	United Kingdom	Japan	Australia
1982	22.06	23.71	30.08	53.35	24.28	13.80	18.16
1983	22.14	22.65	28.89	53.86	25.48	12.16	15.94
1984	24.88	23.50	30.30	56.91	28.47	12.27	17.15
1985	25.81	23.25	31.19	56.02	27.70	11.09	19.16
1986	26.37	20.16	27.30	46.93	26.30	7.39	18.63
1987	25.47	20.51	26.37	47.12	26.39	7.20	17.49
1988	25.81	21.23	27.03	48.62	26.47	7.77	17.45
1989	25.52	22.78	28.94	51.33	27.68	9.19	18.55
1990	25.56	22.58	29.38	49.54	26.91	9.97	17.53
1991	25.55	22.35	25.48	49.32	24.49	8.54	17.14
1992	27.13	21.34	23.78	47.55	25.09	7.83	18.41
1993	29.81	19.85	21.67	44.85	26.62	7.01	19.34
1994	32.98	20.61	22.14	45.99	27.28	7.18	19.82

4.8 Industry Concentration

Following Brainard (1997), I use industry concentration as a proxy for differentiated products. To estimate country and industry concentrations I used import data from the UN World Trade Annual. The data is classified according to the Standard International Trade Classification, Revision 2 (SITC, Rev.2). I used the International Harmonized System to convert the data in SITC, Rev.2 to corresponding 87SIC. I computed the industry concentration values from the Herfindahl Index,

$$R_i \equiv \left(\sum_{j=1}^{J} \eta_{ji}^2\right) * 100 \qquad (18)$$

where

$$\eta_{ji} = \frac{Imports_i^j}{\sum_j Imports_i} \qquad (19)$$

stands for imports in industry i from country j divided by the sum of imports from all countries in industry i.

Table 9 provides the industry concentration values for the seven countries at the manufacturing level. Canada is the most concentrated country. The industry concentration level of the other six countries are about the same with Australia the next highest at an average of 11 percent.

Table 9: Industry Concentration

Year	Canada	France	Germany	Netherlands	United Kingdom	Japan	Australia
1982	50.40	6.60	5.70	8.90	5.70	8.00	10.40
1983	52.10	6.60	5.20	8.70	6.20	7.60	11.20
1984	51.80	6.50	5.60	8.70	6.10	7.30	11.10
1985	50.80	6.70	5.70	9.20	6.30	7.10	11.70
1986	47.90	7.90	6.00	11.30	6.60	7.60	11.50
1987	47.20	8.10	6.00	11.30	6.80	7.00	10.10
1988	44.60	8.10	5.90	11.10	7.00	7.50	10.70
1989	43.70	7.90	5.90	10.70	6.90	7.70	11.00
1990	42.60	7.80	5.80	10.70	6.90	7.50	11.10
1991	41.60	7.50	5.80	10.90	7.30	7.70	10.40
1992	43.40	7.70	5.70	10.60	6.60	7.70	9.90
1993	43.90	7.30	5.30	8.50	6.30	8.00	10.00
1994	46.40	7.40	4.60	8.70	6.60	8.10	10.10

Chapter 5: Results and Conclusion

5.1 Empirical Results

To determine the U.S. multinational firm's decision to export/produce abroad, the sample included seven countries that were destinations for both exports and direct investment. These seven countries accounted in 1994 for 60 percent of MOFA sales and 50 percent of exports by U.S. multinational firms in the manufacturing sector.[24] The analyses covered six industries at the 2-digit 87SIC level, in addition to the aggregate level for thirteen years from 1982-1994.

Summary results of the empirical analyses for each industry and the aggregate level are given in the following subsections. One of the noticeable findings is that the random effect models with the country-specific dummies led to an overall good fit of the whole sample. More specifically, the R^2 for both exports and MOFA sales in all industries and the aggregate level are over 99 percent. This means that 99 percent of the total variance of the dependent variables is "explained" by the independent variables. Thus, the results provide important insights of the multinational's strategic behavior.

The coefficients of the independent variables are mostly of the expected sign (recalling that the expected sign of the coefficients on the openness to trade and industry concentration are indeterminate) and many are statistically significant. Nevertheless, there are a few anomalies. The two main ones is that the coefficients on labor costs (for MOFA sales) and exchange rates (for exports) are often not of the expected sign. Another anomaly is that the coefficients on capital rental rates in both exports and MOFA

[24] The calculation excluded the category, "other manufacturing."

sales models, within an industry, often have the same sign. However, many of these coefficients on the capital rental rates are statistically insignificant.

5.1.1 Food Industry

To determine the multinational's locational decision in the food industry, sales by foreign affiliates and exports are expressed as a function of relative factor prices (capital and labor), exchange rates, GNP per capita of the host country, openness to trade and industry concentration. Table 10 presents the parameter estimates, standard errors and R^2 for the estimable equations (17.1 and 17.2). Columns 2 and 3 of table 10 suggest that decisions to export and produce abroad are not instantaneous. For every 1 percent increase in previous level of exports (MOFA sales), current exports (MOFA sales) increases by 0.50 (0.22) percent. Note that the coefficient on the lagged dependent variable, in general, takes on values between zero to one. A value close to one implies that current level of exports (MOFA sales) is almost identical to previous level of exports (MOFA sales) and thus adjustment is lower. Similarly, a value close to zero suggests that current level of exports (MOFA sales) is different from previous level of exports (MOFA sales) so that the adjustment is higher.

Table 10: Parameter Estimates of the Food Industry[a]

	Lagged Dep. Variable $X_{ei(t-2)}$	Lagged Dep. Variable $X_{mi(t-2)}$	Capital Rental Rates (r_e/r_f)	Wage Rates (w_e/w_f)	GNP per capita $(GNPpc_f)$	Lagged Exchange Rate (δ)	Openness to Trade (τ_f)	Industry Concen-tration (Con_{fi})	R^2
Exports	0.498[b] (0.080)		0.006 (0.066)	-0.489[b] (0.162)	0.102 (0.138)	0.178 (0.125)	0.008 (0.143)	0.184 (0.115)	0.99
MOFA Sales		0.217[b] (0.057)	0.061[b] (0.0.27)	-0.362[b] (0.079)	0.832[b] (0.102)	-0.414[b] (0.068)	-0.641[b] (0.092)	0.357[b] (0.099)	0.99

a Figures in parentheses are standard errors.
b Denotes significance at the 5% level.

As expected, there is a positive relationship between capital rental rates and foreign production. Every 1 percent increase in the relative capital rental rates leads to a 0.06 percent increase in MOFA sales. Note that although the relationship between exports and the rental cost of capital is positive, the coefficient is small and insignificant. In contrast, the coefficients on wage rates are statistically significant for both MOFA sales and exports, but only the latter have the expected sign. This is possible, as wage rates may account for different skill levels. In addition, costs of specific types of labor may vary among countries in ways that are different from the average labor costs (Kravis, and Lipsey, 1982).

Previous research suggests a positive relationship between per capita income of a country and foreign production as well as exports (Gopinath *et al.*, 1999).[25] Namely, demand for qualities or attributes added to primary agricultural products increase as income grow (Gopinath *et al.*, 1999). Holding all else constant, a 1 percent increase in the per capita income of a country, will increase exports by 0.18 percent and MOFA sales

[25] My assumption that GNP per capita may serve as a proxy for market size is supported by findings of similar results with population in place of GNP per capita.

by 0.83 percent. Thus, an increase in per capita income of the host country promotes foreign production more than trade.[26] Since levels of per capita income also indicate development and 75 percent of MOFA sales in the food industry is concentrated in developed countries, this result is hardly surprising.[27] In addition, transport cost in the food industry may be high due to the nature of the commodities (perishable goods).

The two policy-related variables (exchange rates and openness to trade) also reveal important findings. The results on the lagged exchange rates coincide with those of the previous studies [Blonigen (1997), Froot and Stein (1991)]. Namely, from the supply-side of the theoretical model, the findings imply that a depreciation of the foreign currency would promote FDI in the host country by increasing the home country's relative wealth. From the demand-side of the theoretical model, the coefficients on exchange rates for exports also have the expected sign. More specifically, a 1 percent depreciation (appreciation) of the U.S. dollar will lead to a rise (fall) in exports (MOFA sales) by 0.18 (0.41) percent.

There is some evidence for the tariff-jumping hypothesis. For every 1 percent increase in the host country's exposure to foreign competition, exports will increase by 0.01 percent, while MOFA sales will fall by 0.64 percent, all else constant. This means that the MNC utilizes foreign production to avoid trade barriers

The results on the effect of industry concentration are positive. An increase in the industry concentration will increase both exports and MOFA sales, but only the latter is

[26] The higher income elasticities in MOFA sales relative to exports may be that food is a "clean" industry. See the chemical section for a discussion of income-elasticities and environmental quality.

[27] Source: U.S. Department of Commerce, Bureau of Economic Analysis, *U.S. Direct Investment Abroad*, 1994 Benchmark Survey, Final Results, *Table 3e3: Sales by Affiliates, Country by Industry*, 2 August 1999. www.bea.doc.gov/bea/ai/06-99.htm

significant. Holding all else constant, a 1 percent increase in the food industry concentration will increase exports by 0.18 percent and MFOA sales by 0.36 percent. These findings imply that foreign demand for differentiated products in the food industry will promote both exports and MOFA sales but the impact is greater on the latter.

Overall the results of the food industry suggest that (i) GNP per capita, (ii) exchange rates, (iii) openness to trade and (iv) industry concentration are key determinants of the decisions to export/produce abroad. The effect of these factors is stronger in the case of MOFA sales relative to exports.

5.1.2 Chemical Industry

The specification of the exports and MOFA sales equations and the results in the chemical industry are similar to the food industry.

Similarities include a positive and significant relationship (column 3, table 11) between past levels of MOFA sales and exports with respective current levels. However, the values indicate relatively faster adjustment. Likewise, the signs on the capital rental rates are positive, suggesting that an increase in the relative user cost of capital will promote both exports and MOFA sales. The coefficients on wage rates suggest that an increase in relative labor costs will have a negative impact on MOFA sales and exports though only the latter is expected.

Table 11: Parameter Estimates of the Chemical Industry[a]

	Lagged Dep. Variable $X_{ei(t-2)}$	Lagged Dep. Variable $X_{mi(t-2)}$	Capital Rental Rates (r_c/r_f)	Wage Rates (w_c/w_f)	GNP per capita $(GNPpc_f)$	Lagged Exchange Rate (δ)	Openness To Trade (τ_f)	Industry Concen-tration (Con_{fi})	R^2
Exports	0.236[b] (0.080)		0.036 (0.036)	-0.315[b] (0.098)	0.723[b] (0.131)	-0.317[b] (0.100)	0.423[b] (0.113)	0.218 (0.128)	0.99
MOFA Sales		0.293[b] (0.080)	0.010 (0.041)	-0.715[b] (0.117)	0.417[b] (0.141)	-0.283[b] (0.094)	0.067 (0.131)	0.182 (0.166)	0.99

a Figures in parentheses are standard errors.
b Denotes significance at the 5% level.

Per capita income also appears to be a key determinant of exports and MOFA sales. For every 1 percent increase in the host country's per capita income level, exports of chemical products will increase by 0.72 percent and MOFA sales by 0.42 percent, all else constant. Certain characteristics particular to the chemical industry may explain the significantly lower income-elasticity of demand for MOFA sales relative to exports. According to a computation of pollution-intensive industries at the 3-digit SIC level by Mani and Wheeler (1997), "industrial chemical" is the third leading candidate for "dirty" industry. Thus, with stricter regulations in the OECD economies [Mani and Wheeler, (1999), Zarksy, (1999)] and high pollution-intensity in the chemical industry, it is not surprising that the impact of per capita income on MOFA sales is small.

The coefficients on the exchange rates and openness to trade are the only results that are noticeably different from the food industry. First, the signs on the lagged exchange rates for exports and MOFA sales are negative. While the latter suggests that a depreciation of the U.S. dollar would decrease MOFA sales, the former is inconsistent with theoretical expectations. The sensitivity of exports and MOFA sales to movements in the exchange rates may be attributed by extensive use of foreign parts and materials in production (Goldberg and Crockett, 1998). Namely, if the imported input spending relative to total spending is greater then export revenues relative to total revenues, than the higher costs associated with a depreciation of the U.S. dollar may have a negative effect on exports.

Secondly, increase openness to trade in the host country affects both exports and MOFA sales positively. Since foreign production of chemical products may utilize intermediate goods from the home country, a decrease of the trade protection may indeed increase MOFA sales as well as exports. Lastly, the chemical industry concentration proved to be an appropriate proxy for product differentiation. The results suggest that a 1 percent increase in the chemical industry concentration will increase exports by 0.22 percent and MOFA sales by 0.18 percent, all else constant.

Altogether the results of the chemical industry imply that (i) GNP per capita, (ii) openness to trade and (iii) industry concentration are key determinants of the decisions to export/produce abroad. Similar to the food industry, the effect of these factors is stronger in the case of MOFA sales relative to exports.

5.1.3 Metals Industry

Results from the estimation on exports and MOFA sales equation for the metals industry parallel those of the food and chemical industry. As before, past level of exports and MOFA sales are found to have a positive effect on respective current level. Table 12 shows that as expected a 1 percent increase in past MOFA sales (exports) leads to a 0.42

(0.03) percent increase in current MOFA sales (exports). These coefficients suggest that adjustment rates are faster for exports relative to MOFA sales.

In addition, the signs on the capital rental rates are positive like the food and chemical industry. The effect of relative wage rates on exports are as expected with a 1 percent increase in the labor costs leading to a fall in exports by 0.17 percent. The anomaly of a negative impact of an increase in the relative wage rates on affiliate sales persists in the metals industry.

Table 12: Parameter Estimates of the Metals Industry[a]

	Lagged Dep. Variable $X_{ei(t-2)}$	Lagged Dep. Variable $X_{mi(t-2)}$	Capital Rental Rates (r_e/r_f)	Wage Rates (w_e/w_f)	GNP per capita $(GNPpc_f)$	Lagged Exchange Rate (δ)	Openness To Trade (τ_f)	Industry Concen-tration (Con_{fi})	R^2
Exports	0.033 (0.034)		0.258[b] (0.040)	-0.174 (0.115)	1.170[b] (0.113)	-0.093 (0.081)	0.771[b] (0.126)	-0.048 (0.099)	0.99
MOFA Sales		0.415[b] (0.090)	0.061 (0.065)	-0.898[b] (0.147)	0.021 (0.141)	-0.365[b] (0.136)	0.157 (0.168)	-0.057 (0.108)	0.99

a Figures in parentheses are standard errors.
b Denotes significance at the 5% level.

The results in table 12 also indicate that per capita income has a greater impact on exports relative to MOFA sales. For every 1 percent increase in the host country's per capita income level, exports of metal products will increase by 1.17 percent while MOFA sales will increase by only 0.02 percent, all else constant. As with chemical, Mani and Wheeler (1997) also found metals to be a pollution-intensive industry. More specifically, three out of the ten leading candidates for "dirty" industry are in the metals sector with Iron and Steel, Non-Ferrous Metals ranking 1 and 2, respectively.

The effect of exchange rates on MOFA sales is negative (0.37) and significant. Changes in the bilateral exchange rates also have a negative but insignificant impact on exports. The rising costs of imports of intermediate goods from foreign countries for home production that results from the dollar depreciation may outweigh the increase competitiveness relative to the host country.

Increase openness to trade raises both exports and MOFA sales. More specifically, every 1 percent increase in foreign exposure in the metals industry increases exports by 0.77 percent and MOFA sales by 0.16 percent. Similar to the chemical industry, increase openness to trade in the metals industry may promote MOFA sales by increasing exports of intermediate goods from the home to the host country.

However unlike the chemical industry, the effect of an increase in the industry concentration is negative (although insignificant) on both exports and MOFA sales. Since this industry consists basically of metals such as copper and aluminum, differentiating products may not be as feasible as other industries such as food or chemical. Therefore, increase industry concentration may actually discourage exports and MOFA sales.

The overall findings of the metals industry indicate that the key determinants of the decisions to export/produce abroad are (i) GNP per capita and (ii) openness to trade. In addition, these factors have a larger effect on exports relative to MOFA sales.

5.1.4 Machinery Industry

The equations that specify the determinants of exports and MOFA sales in the machinery industry are similar to the food industry. The results correspond with the other industries in that current level of exports and MOFA sales are correlated to respective prior level. From table 13, it is evident that for every 1 percent increase in previous sales by foreign affiliates (exports), current MOFA sales (exports) will rise by 0.13 (0.10). As before, this implies a faster rate of adjustment for exports relative to MOFA sales.

Likewise, the effects of the relative capital rental rates are as expected. Though small, the coefficients suggest that a 1 percent increase in the rental cost of capital will decrease exports by 0.04 percent and increase MOFA sales by 0.01 percent. Moreover, an increase in the relative wage rates by 1 percent will lead to a fall in exports by 0.38 percent, as expected. The negative impact of the relative labor costs on MOFA sales is an anomaly but as mentioned earlier, the finding may account for different skill levels.

Table 13: Parameter Estimates of the Machinery Industry[a]

	Lagged Dep. Variable $X_{ei(t-2)}$	Lagged Dep. Variable $X_{mi(t-2)}$	Capital Rental Rates (r_e/r_f)	Wage Rates (w_e/w_f)	GNP per capita $(GNPpc_f)$	Lagged Exchange Rate (δ)	Openness To Trade (τ_f)	Industry Concen-tration (Con_{fi})	R^2
Exports	0.095 (0.072)		-0.036 (0.044)	-0.384[b] (0.107)	0.584[b] (0.113)	-0.007 (0.099)	0.859[b] (0.105)	-0.475[b] (0.116)	0.99
MOFA Sales		0.128 (0.072)	0.010 (0.056)	-0.703[b] (0.104)	0.657[b] (0.147)	-0.335[b] (0.101)	0.315[b] (0.110)	0.120 (0.136)	0.99

a Figures in parentheses are standard errors.
b Denotes significance at the 5% level.

As with the food industry, per capita income has a greater impact on MOFA sales relative to exports. For every 1 percent increase in the per capita income of the host country, sales of machinery products by foreign affiliates will increase by 0.66 percent while exports will rise by 0.58 percent, all else constant. Also similar to the food industry, there is a higher income-elasticity of demand for MOFA sales relative to exports in the machinery industry because these industries are not "dirty" unlike chemical and primary metals. More specifically, machinery is identified as one of the five "cleanest" industries in U.S. manufacturing sector (Mani and Wheeler, 1999).

Changes in the bilateral exchange rates have a negative impact on MOFA sales (0.34) and exports (0.01), however, only the former is significant. A decrease in trade protection rises both exports (0.86) and MOFA sales (0.32). However, increase industry concentration has a positive effect on MOFA sales but a negative impact on exports. It is likely that higher product differentiation may discourage exports if the products require certain host country attributes along with firm-specific technology. The addition of host country attributes such as customer-oriented support facilities explains the positive relationship between MOFA sales and higher industry concentration. In particular, a lack of such support facilities in the machinery industry may decrease the level of foreign demand since these services represent the MNC's permanent commitment to the host country (Barrell and Pain, 1996).

Collectively, the results of the machinery industry suggest that the key determinants of the decisions to export/produce abroad are (i) GNP per capita, (ii) openness to trade and (iii) industry concentration. The effect of these factors is stronger in the case of MOFA sales relative to exports, except for income per capita.

5.1.5 Electronic Industry

The equation specifications for exports and MOFA sales in the electronic industry are similar to the food industry. Prior exports and MOFA sales have a positive impact on current exports and affiliate sales. These results coincide with the other industries in suggesting that the decisions to export and produce abroad are not instantaneous. Moreover, adjustment is higher for exports than MOFA sales.

The effects of the relative capital rental rates on both exports and MOFA sales are positive though only the latter is expected. There is a negative relationship between relative labor costs and exports. For every 1 percent increase in the relative wage rates, exports will decrease by 0.05 percent. There is a similar negative impact of labor cost on MOFA sales.

Table 14: Parameter Estimates of the Electronic Industry[a]

	Lagged Dep. Variable $X_{ei(t-2)}$	Lagged Dep. Variable $X_{mi(t-2)}$	Capital Rental Rates (r_e/r_f)	Wage Rates (w_e/w_f)	GNP per capita $(GNPpc_f)$	Lagged Exchange Rate (δ)	Openness To Trade (τ_f)	Industry Concen-tration (Con_{fi})	R^2
Exports	0.166[b] (0.061)		0.010 (0.043)	-0.049 (0.104)	1.289[b] (0.118)	-0.451[b] (0.104)	0.381[b] (0.131)	-0.345[b] (0.085)	0.99
MOFA Sales		0.326[b] (0.047)	0.152 (0.114)	-0.183 (0.177)	1.091[b] (0.179)	-0.342[b] (0.047)	-0.243[b] (0.117)	0.255[b] (0.090)	0.99

a Figures in parentheses are standard errors.
b Denotes significance at the 5% level.

The positive impact of per capita income is greater on exports relative to MOFA sales, although the difference is not as wide as it is for the "dirty" industries. For every 1 percent increase in the host country's per capita income, sales of electronic products by exports will increase by 1.29 percent and foreign affiliates by 1.09 percent, all else constant. As expected, there is a negative relationship between the depreciation of the U.S. dollar and MOFA sales. However, (as before) the negative effect of a U.S. dollar depreciation on exports may be attributed by higher cost of imported materials.

There is some evidence of tariff-jumping in the electronic industry as an increase in the host country's exposure to the foreign competition promotes exports and reduces MOFA sales. Specifically, an increase in the openness to trade by 1 percent leads to a 0.38 percent expansion in exports and 0.24 percent decline in MOFA sales. The relationship between product differentiation and MOFA sales (0.26) is positive. As discussed earlier, the need for locally established customer-oriented service facilities might explain the negative effect of higher industry concentration on export (0.35).

Similar to the other industries, the key determinants of the decisions to export/produce abroad in the electronic industry are (i) GNP per capita, (ii) openness to trade and (iii) industry concentration. The results also suggest that export is more sensitive to changes in these factors relative to MOFA sales.

5.1.6 Transportation Industry

For the transportation industry, the determinants of sales by foreign affiliates and exports are specified in equations that are similar to the food industry. As with the other industries, previous MOFA sales have a positive impact on current affiliate sales. However, the results in table 15 also suggest that past level of exports have a negative effect on current the export level. This implies that long-run adjustment is slower than short-run rate.

The results on factor prices are mixed as before. The negative relationship between factor prices and exports are as expected. Holding all else constant, every 1 percent increase in the relative capital rental (wage) rates will decline exports by 0.57 (0.77) percent. There is also a negative relationship between factor prices and foreign production although the effect of capital rental rate is small and insignificant. Barrell and Pain (1996) note that previous studies found that a rise in the home country's capital rental rates may reduce direct investments as the multinational switch to borrowing in the host country.

Table 15: Parameter Estimates of the Transportation Industry[a]

	Lagged Dep. Variable $X_{ei(t-2)}$	Lagged Dep. Variable $X_{mi(t-2)}$	Capital Rental Rates (r_e/r_f)	Wage Rates (w_e/w_f)	GNP per capita $(GNPpc_f)$	Lagged Exchange Rate (δ)	Openness to Trade (τ_f)	Industry Concen-tration (Con_{fi})	R^2
Exports	-0.150[b] (0.073)		-0.573[b] (0.089)	-0.774[b] (0.235)	1.725[b] (0.206)	-0.987[b] (0.184)	1.049[b] (0.196)	0.073 (0.199)	0.99
MOFA Sales		0.195[b] (0.088)	-0.006 (0.088)	-0.444[b] (0.223)	0.812[b] (0.211)	-0.522[b] (0.181)	-1.024[b] (0.306)	0.260 (0.202)	0.99

a Figures in parentheses are standard errors.
b Denotes significance at the 5% level.

An increase in the per capita income of the host country has a larger positive effect on exports relative to MOFA sales. For every 1 percent increase in the per capita income level, exports of transportation equipment will rise by 1.73 percent and MOFA sales by 0.81 percent, all else constant. Unlike the metals and chemical industries, transportation is ranked as one of the five cleanest industries (Mani and Wheeler, 1999).

However, exports may be more sensitive to changes in income relative to direct MOFA sales if the foreign income-elasticity of demand for U.S.-made transportation equipment relative to host country-made equipment outweighs the benefit of nonpolluting-intensive production.

As expected, there is a negative impact of a depreciation of the U.S. dollar on MOFA sales (0.52). Contrary to prediction, the positive effect of dollar depreciation may be outweighed by increasing import costs thus leading to a negative relationship between exchange rate movements and exports. Increase openness to trade promotes export (1.05) and discourages MOFA sales (1.02), once again tariff-jumping. In addition, greater product differentiation encourages both exports and MOFA sales, but insignificantly. In particular, a 1 percent increase in the industry concentration will expand MOFA sales by 0.26 percent and exports by 0.07 percent.

As a whole, the findings of the transportation industry imply that (i) GNP per capita, (ii) openness to trade and (iii) industry concentration are key determinants of the decisions to export/produce abroad. There is also some evidence that the effect of these factors is stronger in the case of exports relative to MOFA sales.

5.1.7 Aggregate Manufacturing Level

The specification of exports and MOFA sales at the aggregate manufacturing level is similar to those at the industry level. It aggregates all six industries and includes "other" industries. The purpose of doing this is to confirm if the observed industry level results are also reflected at the aggregate level. Table 16 indicates that similar to the industry results, previous MOFA sales have a positive impact on current affiliate sales. There is a negative, though insignificant effect of past export levels on current exports.

The mixed results on factor prices persist and continue to follow the tradition of prior studies [Baldwin, (1979), Gopinath *et al.*, (1999), Kravis and Lipsey (1982)]. The negative relationship between factor prices and exports are more significant for relative wage rates than the capital rental rates. Namely, a 1 percent increase in the relative wage rate will decrease exports by 0.29 percent while an equal percent rise in the relative capital rental rates will decline exports by only 0.05 percent. Coinciding with the results of the transportation industry, the relationship between factor prices and MOFA sales is negative. Note that the effect of the capital rental rates on MOFA sales is small and insignificant. The negative impact of the relative wage rates on MOFA sales could reflect the differing levels of labor efficiency in different locations (Barrell and Pain, 1996).

Table 16: Parameter Estimates of the Aggregate Manufacturing Level[a]

	Lagged Dep. Variable $X_{ei(t-2)}$	Lagged Dep. Variable $X_{mi(t-2)}$	Capital Rental Rates (r_e/r_f)	Wage Rates (w_e/w_f)	GNP per capita $(GNPpc_f)$	Lagged Exchange Rate (δ)	Openness To Trade (τ_f)	Industry Concen-tration (Con_{fi})	R^2
Exports	-0.050 (0.057)		-0.052 (0.032)	-0.285[b] (0.112)	1.160[b] (0.096)	-0.343[b] (0.081)	0.552[b] (0.110)	-0.004 (0.107)	0.99
MOFA Sales		0.107[b] (0.051)	-0.028 (0.026)	-0.600[b] (0.074)	0.721[b] (0.094)	-0.299[b] (0.054)	0.051 (0.094)	0.146[b] (0.071)	0.99

a Figures in parentheses are standard errors.
b Denotes significance at the 5 percent level.

The positive and significant income elasticities support findings in previous studies [Lipsey and Weiss (1981), Wheeler and Mody (1992)]. The results imply that at the aggregate level, increases in the host country's per capita income has a larger impact on exports than MOFA sales. More specifically, a 1 percent increase in the per capita income increases exports by 1.12 percent and affiliate sales by 0.72 percent, all else constant. This phenomenon is explained by the increase in the demand for environmental quality (i.e., less pollution-intensive or "dirty" industries) as income rises (Mani and Wheeler, 1999).

The result on the effect of exchange rates movements on direct investment is consistent with those reported by Blonigen (1997) and Froot and Stein (1991). More specifically, FDI is likely to decrease in an imperfect market where the currency of the home country depreciates relative to the host country. As previously mentioned, the negative relationship between the bilateral exchange rate and exports may account for the rising cost of imported materials for home production.

Similar to most of the industry-level results, the impact of an increase in the openness to trade has a positive impact on both export and MOFA sales. Specifically, the effect of an increase in foreign exposure is greater on export (0.55) relative to MOFA sales (0.05). Table 16 also shows that the results of the concentration variable support previous research (Baldwin 1979). Namely, product differention has a positive effect on affiliates sales and negative effect on exports. Note that the impact of higher industry concentration on exports is very small and insignificant. As mentioned earlier, this negative relationship between exports and product differentitaion may be attributed to the foreign customer's demand for locally-established service facilities, particularly in industries that require technical support (i.e., machinery and electronic).

Overall, the results at the aggregate manufacturing level suggest that (i) GNP per capita, (ii) openness to trade and (iii) industry concentration are key determinants of the decisions to export/produce abroad. These findings also imply that the effect of these factors is stronger in the case of exports relative to affiliate sale, except for industry concentration.

5.2 Summary and Conclusions

5.2.1 Summary of Major Findings

In choosing locations to serve the foreign market, the U.S. multinational firm seeks conditions that will optimize the return on its investment. With this in mind, I attempted to model the MNC's locational decision based on the Chamberlinian monopolistic competition theory with differentiated products. The theoretical framework analyzed the MNC's choice between exports and MOFA sales as means to supply the foreign market.

The empirical model utilized data on foreign sales (exports and MOFA sales) at the aggregate manufacturing sector and six 2-digit SIC industries in seven developed countries for thirteen years from 1982-1994. The model incorporated factors such as per capita income that has a simultaneous effect on the MNC's strategic decision. In addition, the empirical model also analyzed the extent to which the relative cost of production (capital and labor), exchange rates, openness to trade and industry concentration promote sales by foreign affiliates and exports.

My study differs from previous efforts in that it brings together studies on factor prices (Markusen, 1983) with those that included proxies for trade barriers [Gopinath et al. (1999), Wheeler and Mody (1992)], exchange rates (Blonigen, 1997), and income per capita (Graham, 1995) in a model that focus on the forces causing either substitution/complementarity.

Overall, the results are successful in determining key factors in the decision to export/produce abroad. As table 17 suggests, holding all else constant, an increase in the host country's GNP per capita has a stronger effect on exports relative to the case of MOFA sales, except for the food and machinery industries. These results are not surprising since the demand for environmental quality rises with income and the manufacturing sector consists of "dirty" industries such as chemical and metals.

Table 17: Parameter Estimates of Income per Capita by Industry[a]

	Mfg	Food	Chemical	Metals	Machinery	Electronic	Transportation
Exports	1.160[b] (0.096)	0.102 (0.138)	0.723[b] (0.131)	1.170[b] (0.113)	0.584[b] (0.113)	1.289[b] (0.118)	1.725[b] (0.206)
MOFA Sales	0.721[b] (0.094)	0.832[b] (0.102)	0.417[b] (0.141)	0.021 (0.141)	0.657[b] (0.147)	1.091[b] (0.179)	0.812[b] (0.211)

a Figures in parentheses are standard errors.
b Denotes significance at the 5 percent level.

Likewise, the proxy for openness to trade is also a significant factor in the decisions to export/produce abroad. Table 18 indicates evidence of tariff-hopping. Increased foreign exposure in the food, electronic and transportation industries decreases MOFA sales. In contrast, increase openness to trade promotes sales in chemical, metals and machinery by both exports and foreign affiliates. Note, however, that the effect on exports is stronger relative to MOFA sales.

Table 18: Parameter Estimates of Openness to Trade by Industry[a]

	Mfg	Food	Chemical	Metals	Machinery	Electronic	Transportation
Exports	0.552[b] (0.110)	0.008 (0.143)	0.423[b] (0.113)	0.771[b] (0.126)	0.859[b] (0.105)	0.381[b] (0.131)	1.049[b] (0.196)
MOFA Sales	0.051 (0.094)	-0.641[b] (0.092)	0.067 (0.131)	0.157 (0.168)	0.315[b] (0.110)	-0.243[b] (0.117)	-1.024[b] (0.306)

a Figures in parentheses are standard errors.
b Denotes significance at the 5 percent level.

Another important determinant of the decisions to export/produce abroad is industry concentration. With a DS-type preference, greater product differentiation is likely to increase foreign consumer demand. This is supported by the results of table 19 for MOFA sales in all industries, except metals. But the outcome of exports in some industries such as metals, machinery and electronic are contrary to expectation. However, certain manufacturing activities, particularly the machinery industry require host country attributes such as sales or service facilities as evidence to the foreign customers of permanent commitment to the local market [Barrell and Pain (1996), Lipsey and Weiss (1984)]. More importantly, lack of such commitment is a deterrent to sales (Lipsey and Weiss, 1984).

Table 19: Parameter Estimates of Industry Concentration[a]

	Mfg	Food	Chemical	Metals	Machinery	Electronic	Transportation
Exports	-0.004 (0.107)	0.184 (0.115)	0.218 (0.128)	-0.048 (0.099)	-0.475[b] (0.116)	-0.345[b] (0.085)	0.073 (0.199)
MOFA Sales	0.146[b] (0.071)	0.357[b] (0.099)	0.182 (0.166)	-0.057 (0.108)	0.120 (0.136)	0.255[b] (0.090)	0.260 (0.202)

a Figures in parentheses are standard errors.
b Denotes significance at the 5 percent level.

In contrast to the results on per capita income, openness to trade and industry concentration variables, the results on factor prices and exchange rates are not as expected. More specifically, the positive coefficients on the capital rental rates for the food, chemical, metals, and electronic industries suggest that an increase in the U.S. user cost of capital relative to the host country will lead to a rise in exports. Likewise, the unexpected negative sign on wage rates implies that an increase in the U.S. labor costs relative to the host country will decrease MOFA sales. The negative relationship between a depreciation of the U.S. dollar and exports also contradicts theoretical expectations. It is likely that these findings are the result of measurement errors. For example, the negative coefficients on the wage rates may reflect a lack of a comprehensive measure of labor costs and quality across the countries. In addition, the unexpected results may be due to the use of wage rates at the manufacturing level instead of the industry level (which is currently unavailable). The results on the wage rates may also capture the host country's income. Similarly, the positive coefficients on the capital rental rates may account for global deregulation in the capital markets which lowers differences in the user cost of capital. Moreover, the unexpected negative relationship between exchange rates and exports may be attributed to rising costs of imported-intermediate goods for home production.

5.2.2 Conclusions

For my thesis, I focused on understanding the determinants of exports and MOFA sales. To contribute to the complementary/substitution discussion between exports and FDI, I posed several questions concerning the role of per capita income, factor prices and trade barriers on the two modes of foreign service. The empirical results suggest that high level of per capita income does not necessarily indicate more trade relative to FDI or vice verse. Specifically, higher per capita income promotes more exports relative to MOFA sales in the chemical and metals industries, as foreign demand for environmental quality increases with income. Thus, the results do not support claims that increases in FDI, resulting from higher host country per capita income will lead to a rise in the number of jobs lost to the foreign country.

The findings indicate that an increase in trade protection causes a substitution between exports and FDI, as the multinational firm utilizes foreign production to jump over tariff barriers. Since an increase in the openness to trade increases exports more than MOFA sales, it is likely that U.S. efforts to decrease multilateral trade restrictions will help to maintain jobs at home.

The results of the relative factor prices do not provide evidence of locational advantages. Due to decreasing capital market barriers, it may be that differences in capital rental rates are not significant enough to serve as a locational advantage.

Similarly, the substitution/complementary relationship between exports an FDI is undetermined from the differences in labor costs. Some of the reasons could that there are relatively small differences in wage rates between the high-income countries, in addition to a lack of a comprehensive measure of labor costs and quality across the countries.

Until more detailed data becomes available, the results suggest that factors such as per capita income and openness to trade are useful in explaining the multinational's decision to export/foreign produce. However, in the future, I would like to test the theoretical model with data at the 3 or 4-digit SIC level (preferably firm-level). In addition, it would be beneficial to expand the pool of countries to include not only more developed countries but also a good number of less-developing countries. Lastly, I would simultaneously model outward and inward FDI, exports and imports to capture the impact of activities of foreign competition on the multinational's strategic decision and hence the relationship between exports and FDI.

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APPENDICES

Appendix A: Derivation of Consumer Demand for Differentiated Products

The consumer utility function is

$$\text{(A.1)} \qquad U = Xo + \left(\frac{\theta}{\theta - 1}\right) X^{(\theta - 1)/\theta} \qquad , \theta > 0 , \theta \neq 1$$

where

$$\text{(A.2)} \qquad X = \left[n_f X_f^{(\varepsilon - 1)/\varepsilon} + (n_e - m) X_e^{(\varepsilon - 1)/\varepsilon} + m X_m^{(\varepsilon - 1)/\varepsilon} \right]^{\varepsilon/(\varepsilon - 1)} \qquad , \varepsilon > 1$$

Substituting (A.2) into (A.1) gives,

$$\text{(A.3)} \qquad U = Xo + \left(\frac{\theta}{\theta - 1}\right) \left[n_f X_f^{(\varepsilon - 1)/\varepsilon} + (n_e - m) X_e^{(\varepsilon - 1)/\varepsilon} + m X_m^{(\varepsilon - 1)/\varepsilon} \right]^{\left(\frac{\varepsilon}{\varepsilon - 1}\right)\left(\frac{\theta - 1}{\theta}\right)}$$

The consumer budget constraint is

$$\text{(A.4)} \qquad E = X_o + n_f P_f X_f + (n_e - m) P_e X_e + m P_m X_m$$

Setting up the Lagrangian,

$$\text{(A.5)} \qquad L = Xo + \left(\frac{\theta}{\theta - 1}\right) \left[n_f X_f^{(\varepsilon - 1)/\varepsilon} + (n_e - m) X_e^{(\varepsilon - 1)/\varepsilon} + m X_m^{(\varepsilon - 1)/\varepsilon} \right]^{\left(\frac{\varepsilon}{\varepsilon - 1}\right)\left(\frac{\theta - 1}{\theta}\right)}$$

$$+ \lambda[X_o - n_f P_f X_f - (n_e - m) P_e X_e - m P_m X_m]$$

and differentiating with respect to the varieties gives,

$$(A.6.1)\quad \frac{\partial L}{\partial X_f} = \left(\frac{\theta}{\theta - 1}\right)\left(\frac{\theta - 1}{\theta}\right)\left(\frac{\varepsilon}{\varepsilon - 1}\right)\left[n_f X_f^{(\varepsilon - 1)/\varepsilon} + (n_e - m)X_e^{(\varepsilon - 1)/\varepsilon} + mX_m^{(\varepsilon - 1)/\varepsilon}\right]^{\left(\frac{\varepsilon}{\varepsilon - 1}\right)\left(\frac{\theta - 1}{\theta}\right) - 1} *$$

$$\left(\frac{\varepsilon - 1}{\varepsilon}\right) n_f X_f^{\left(\frac{\varepsilon - 1}{\varepsilon}\right) - 1} - \lambda n_f P_f = 0$$

$$(A.6.2)\quad \frac{\partial L}{\partial X_e} = \left(\frac{\theta}{\theta - 1}\right)\left(\frac{\theta - 1}{\theta}\right)\left(\frac{\varepsilon}{\varepsilon - 1}\right)\left[n_f X_f^{(\varepsilon - 1)/\varepsilon} + (n_e - m)X_e^{(\varepsilon - 1)/\varepsilon} + mX_m^{(\varepsilon - 1)/\varepsilon}\right]^{\left(\frac{\varepsilon}{\varepsilon - 1}\right)\left(\frac{\theta - 1}{\theta}\right) - 1} *$$

$$\left(\frac{\varepsilon - 1}{\varepsilon}\right) (n_e - m)Xe^{\left(\frac{\varepsilon - 1}{\varepsilon}\right) - 1} - \lambda (n_e - m) P_e = 0$$

$$(A.6.3)\quad \frac{\partial L}{\partial X_m} = \left(\frac{\theta}{\theta - 1}\right)\left(\frac{\theta - 1}{\theta}\right)\left(\frac{\varepsilon}{\varepsilon - 1}\right)\left[n_f X_f^{(\varepsilon - 1)/\varepsilon} + (n_e - m)X_e^{(\varepsilon - 1)/\varepsilon} + mX_m^{(\varepsilon - 1)/\varepsilon}\right]^{\left(\frac{\varepsilon}{\varepsilon - 1}\right)\left(\frac{\theta - 1}{\theta}\right) - 1} *$$

$$\left(\frac{\varepsilon - 1}{\varepsilon}\right) mX_m^{\left(\frac{\varepsilon - 1}{\varepsilon}\right) - 1} - \lambda m P_m = 0.$$

Simplifying equation (A.6) gives,

$$X_f^{\left(\frac{\varepsilon-1}{\varepsilon}\right)-1}\left[n_f X_f^{(\varepsilon-1)/\varepsilon}+(n_e-m)X_e^{(\varepsilon-1)/\varepsilon}+mX_m^{(\varepsilon-1)/\varepsilon}\right]^{\left(\frac{\varepsilon}{\varepsilon-1}\right)\left(\frac{\theta-1}{\theta}\right)-1}=\lambda P_f \tag{A.7.1}$$

$$X_e^{\left(\frac{\varepsilon-1}{\varepsilon}\right)-1}\left[n_f X_f^{(\varepsilon-1)/\varepsilon}+(n_e-m)X_e^{(\varepsilon-1)/\varepsilon}+mX_m^{(\varepsilon-1)/\varepsilon}\right]^{\left(\frac{\varepsilon}{\varepsilon-1}\right)\left(\frac{\theta-1}{\theta}\right)-1}=\lambda P_e \tag{A.7.2}$$

$$X_m^{\left(\frac{\varepsilon-1}{\varepsilon}\right)-1}\left[n_f X_f^{(\varepsilon-1)/\varepsilon}+(n_e-m)X_e^{(\varepsilon-1)/\varepsilon}+mX_m^{(\varepsilon-1)/\varepsilon}\right]^{\left(\frac{\varepsilon}{\varepsilon-1}\right)\left(\frac{\theta-1}{\theta}\right)-1}=\lambda P_m \tag{A.7.3}$$

Then equating (A.7.1) to (A.7.2) gives,

$$\frac{X_f^{\left(\frac{\varepsilon-1}{\varepsilon}\right)-1}\left[n_f X_f^{(\varepsilon-1)/\varepsilon}+(n_e-m)X_e^{(\varepsilon-1)/\varepsilon}+mX_m^{(\varepsilon-1)/\varepsilon}\right]^{\left(\frac{\varepsilon}{\varepsilon-1}\right)\left(\frac{\theta-1}{\theta}\right)-1}}{X_e^{\left(\frac{\varepsilon-1}{\varepsilon}\right)-1}\left[n_f X_f^{(\varepsilon-1)/\varepsilon}+(n_e-m)X_e^{(\varepsilon-1)/\varepsilon}+mX_m^{(\varepsilon-1)/\varepsilon}\right]^{\left(\frac{\varepsilon}{\varepsilon-1}\right)\left(\frac{\theta-1}{\theta}\right)-1}}=\frac{\lambda P_f}{\lambda P_e} \tag{A.8.1}$$

$$\frac{X_f^{\left(\frac{\varepsilon-1}{\varepsilon}\right)-1}}{X_e^{\left(\frac{\varepsilon-1}{\varepsilon}\right)-1}}=\frac{P_f}{P_e} \tag{A.8.1.1}$$

or

(A.8.1.2) $$X_f = X_e P_f^{-\varepsilon} P_e^{\varepsilon}.$$

Similarly, equating (A.7.2) to (A.7.3) gives,

(A.8.2.2) $$X_m = X_e P_m^{-\varepsilon} P_e^{\varepsilon}.$$

Substituting equation (A.8) into (A.2) to get,

(A.9) $$X = \left[n_f (X_e P_f^{-\varepsilon} P_e^{\varepsilon})^{(\varepsilon-1)/\varepsilon} + (n_e - m) X_e^{(\varepsilon-1)/\varepsilon} + m(X_e P_m^{-\varepsilon} P_e^{\varepsilon})^{(\varepsilon-1)/\varepsilon} \right]^{\varepsilon/(\varepsilon-1)}$$

$$= X_e [n_f P_f^{1-\varepsilon} P_e^{\varepsilon-1} + n_e + m P_m^{1-\varepsilon} P_e^{\varepsilon-1}]^{\varepsilon/(\varepsilon-1)}$$

$$= X_e (P_e^{\varepsilon-1})^{\varepsilon/(\varepsilon-1)} [n_f P_f^{1-\varepsilon} + n_e P_e^{1-\varepsilon} + m P_m^{1-\varepsilon}]^{\varepsilon/(\varepsilon-1)}$$

$$= X_e P_e^{\varepsilon} [n_f P_f^{1-\varepsilon} + n_e P_e^{1-\varepsilon} + m P_m^{1-\varepsilon}]^{\varepsilon/(\varepsilon-1)}$$

Solving for X_e in equation (A.9) gives,

(A.10) $$X_e = X P_e^{-\varepsilon} [n_f P_f^{1-\varepsilon} + n_e P_e^{1-\varepsilon} + m P_m^{1-\varepsilon}]^{(\varepsilon-1)/\varepsilon}$$

Let $q = [n_f P_f^{1-\varepsilon} + n_e P_e^{1-\varepsilon} + m P_m^{1-\varepsilon}]^{1/(\varepsilon - 1)}$, then equation (A.10) becomes

(A.11) $$X_e = P_e^{-\varepsilon} q^{\varepsilon} X \qquad \text{, where } X = q^{-\theta}.$$

Thus the demand for the different varieties is given by,

(A.12) $$X_j = P_j^{-\varepsilon} q^{\varepsilon - \theta} \qquad , j = f, e, m.$$

The equation $X = q^{-\theta}$ is solved by maximizing the consumer utility from (A.1),

$$U = Xo + \left(\frac{\theta}{\theta - 1}\right) X^{(\theta - 1)/\theta} \qquad \text{subject to } X_o + qX = E.$$

Differentiating the Lagrangian with respect to the numeraire and the differentiated product gives,

(A.13.1) $$\frac{\partial L}{\partial X_o} = 1 - \lambda = 0 \qquad \text{or} \qquad \lambda = 1$$

and

(A.13.2) $$\frac{\partial L}{\partial X_m} = \left(\frac{\theta}{\theta - 1}\right)\left(\frac{\theta - 1}{\theta}\right) X^{\left(\frac{\theta - 1}{\theta}\right) - 1} - \lambda q = 0 \qquad \text{or} \qquad X = q^{-\theta}.$$

Appendix B: Homogeneous Products

In this appendix, I will derive the multinational's market share for homogenous products. The utility function provided below is the same as the one stated in equation (1):

(B.1) $$U = U[u_1(\cdot), u_2(\cdot), \ldots, u_I(\cdot)] .$$

If the products are homogeneous than $u_i(D_i) \equiv D_i$ and $u_i(\cdot)$ depends only on the quantity consumed D_i (Helpman and Krugman, 1985). Assuming a duopoly model, the inverse demand function for the homogenous goods is given by

(B.2) $$P(X) = A - X$$

where X is the sum of all production for the foreign market by the U.S. firm (X_1) and the foreign firm (X_2). The production costs of the two firms are C_1 and C_2 where $(C_1 - C_2) < \varepsilon$ for any $\varepsilon > 0$. The cost assumption ensures that the multinational's marginal costs do not differ significantly from the foreign firm.

To determine their foreign market share, the two firms simultaneously select their level of production, X_j (j = h for the U.S. multinational firm, f for the foreign firm). Taking the other firm's output as given, firm j's problem is to maximize the following profit function

(B.3) $$\Pi_j(X_i, X_j) = \max\,(A - X)X_j - C_jX_j \quad , i \neq j\,.$$

By differentiating the above profit equation (B.3) with respect to X_j, I obtain the following reaction functions,

(B.4.1) $$X_h^* = (A - X_f^* - C_h)/2, \qquad \text{if } X_f^* < A - C_1$$

(B.4.2) $$X_f^* = (A - X_h^* - C_f)/2, \qquad \text{if } X_h^* < A - C_2$$

where X_j^* (j = h, m) is firm j's optimal output level. By substituting equation (B.4.1) into (B.4.2), the Nash Equilibrium for this duopoly model are

(B.5.1) $$X_h^* = (A - 2C_h - C_f)/2$$

(B.5.2) $$X_f^* = (A - 2C_h - C_f)/2\,.$$

After deciding the optimal level of production, the U.S. multinational firm chooses the mode by which to serve the foreign market; i.e. either via exports and/or MOFA sales. With its given market share, the process by which the firm decides on where and what to produce is the same as with differentiated products.

Appendix C: Derivation of the U.S. Multinational Firm's Profit Function

The multinational's objective function is to

(C.1) $$\max\ (P_j - C_j)n_jX_j$$

subject to the demand equation,

(C.2) $$X_j = P_j^{-\varepsilon} q^{\varepsilon - \theta}$$

or

(C.1.1) $$\max\ n_jP_j^{-\varepsilon} q^{\varepsilon - \theta} - n_jc_jP_j^{-\varepsilon} q^{\varepsilon - \theta} \qquad , j = f, e, m.$$

Differentiating (C.1) with respect to P_j gives,

(C.2) $$(1 - \varepsilon)n_jP_j^{-\varepsilon} q^{\varepsilon - \theta} - (-\varepsilon)n_jC_jP_j^{-\varepsilon - 1} q^{\varepsilon - \theta} = 0$$

which simplifies to

(C.3) $$P_j = \left(\frac{-\varepsilon}{1 - \varepsilon}\right)C_j$$

$$= \left(\frac{\varepsilon}{\varepsilon - 1}\right)C_j.$$

I assume that there are tariffs (τ) on exports. Then by using the demand equation (C.2) and substituting prices (C.3) into the objective function (C.1) gives the multinational's profit function for exports and foreign production.

(C.4.1) $$\Pi_e = (n_f - m)P_eX_e/\varepsilon$$

(C.4.2) $$\Pi_m = mP_mX_m/\varepsilon\ .$$

Appendix D: Panel Data

Panel or longitudinal data sets pool time series and cross sections. According to Greene (1997), the fundamental advantage of using a panel data set over a cross-section is the greater flexibility available in modeling differences in behavior across individuals. The general form of a regression model using panel data is

$$Y_{it} = \alpha_i + \beta`X_{it} + u_{it} \quad \text{(D.1)}$$

where α_i is the individual effect and X_{it} has K regressors, not including the constant term.[28] One approach used to generalize this model is the fixed effects where α_i is taken to be a group specific constant term. Differences between cross-section units are viewed as parametric shifts of the regression function (i.e., the slope coefficient is the same for all cross-section units and only the intercepts are different). In addition, the model applies conditionally on the effects present in the study, not to additional ones outside the sample. However, the benefit of the fixed effects approach is that there are no assumptions requiring that the individual effects be uncorrelated with the other regressors.

The other approach, random effects, specifies that α_i is a group specific disturbance similar to u_{it}. More specifically, α_i is the total effect of several factors that are specific to the cross-section units. This "specific ignorance" can be treated a as random variable in the same way as the "general ignorance" represented by u_{it}. This

[28] See Greene (1997) chapter 14 for a mathematical interpretation.

model is appropriate for sampled cross-section units drawn from a large population. In addition, the random effects approach is less costly in terms of degree of freedom lost as compared to the fixed effects approach, which requires cross-sectional dummy variables. However, the random effects treatment may suffer from inconsistency due to omitted variables as this approach assumes that the individual effects are uncorrelated with the other regressors. Moreover, Maddala (1977) notes that if there is any systematic relationship between α_i and the level of the X's, it is not reasonable to assume that α_i is random.

Accounting for the differences between the random effects and fixed effects approaches, I utilize a combination of both models in my empirical analysis. Namely, I incorporate country dummy variables in my random effects model. This statistical technique allows me to obtain estimates of exports/MOFA sales factor coefficients that are free of country-specific bias such as language and culture while allowing for random individual differences such as production costs and market size. The overall advantage is that it combines the benefits from both fixed effects and random effects approaches.

Appendix E: Second-Period Lag as an Instrumental Variable

In this appendix, I will build on Greene (1997) to prove that least squares will no longer be unbiased or consistent if the regression contains a first-period lag of the dependent variable. In addition, I will go further by showing that the second-period lagged dependent variable may be used as an instrumental variable (IV) for the first-period lag to obtain consistent least squares.

The first proof begins with a simply equation where the dependent variable is regressed on its first-period lag and an error term,

$$(E.1) \qquad Y_t = \beta Y_{t-1} + u_t$$

and

$$(E.2) \qquad u_t = \rho u_{t-1} + e_t\,.$$

Following Greene (1997), I restrict $|\rho| < 1$ to allow for the stationarity assumption. This implies that,

$$(E.3.1) \qquad E[u_t] = 0$$

and

$$(E.3.2) \qquad \mathrm{Var}[u_t] = \frac{\sigma_e^2}{1 - \rho^2} = \sigma_u^2$$

Substituting (E.2) into (E.1) shows that the least squares of the first period lagged are no longer unbiased and consistent since the regressor and the disturbance are correlated.[29] More specifically, since the process is stationary and e_t is uncorrelated with everything that precedes it,

$$\text{(E.4)} \qquad \begin{aligned} \mathrm{Cov}[Y_{t-1}, u_t] &= \mathrm{Cov}[Y_{t-1}, \rho u_{t-1} + e_t] \\ &= \rho \mathrm{Cov}[Y_{t-1}, u_{t-1}] \\ &= \rho \mathrm{Cov}[Y_t, u_t]\,. \end{aligned}$$

Further substitution of (E.4) with (E.1) gives

$$\begin{aligned} \rho \mathrm{Cov}[Y_t, u_t] &= \rho \mathrm{Cov}[\beta Y_{t-1} + u_t, u_t] \\ &= \rho\{\beta \mathrm{Cov}[Y_{t-1}, u_t] + \mathrm{Cov}[u_t, u_t]\} \\ &= \rho\{\beta \mathrm{Cov}[Y_{t-1}, u_t] + \mathrm{Var}[u_t]\} \end{aligned}$$

so that

$$\text{(E.4.1)} \qquad \begin{aligned} &= \rho\beta \mathrm{Cov}[Y_{t-1}, u_t] + \rho \mathrm{Cov}[u_t, u_t] \\ &= \frac{\rho\sigma_e^2}{(1 - \beta\rho)(1 - \rho^2)}\,. \end{aligned}$$

Continuing, the variance of (E.1) is

$$\text{(E.5)} \qquad \mathrm{Var}[Y_t] = \beta^2 \mathrm{Var}[Y_{t-1}] + \mathrm{Var}[u_t] + 2\beta \mathrm{Cov}[Y_{t-1}, u_t]$$

---

[29] The more general case that includes regressors (X) involves more complicated algebra, but gives the

since the process is stationary, $\mathrm{Var}[Y_t] = \mathrm{Var}[Y_{t-1}]$. Substituting for $\mathrm{Var}[u_t]$ from (E.3.2) and $\mathrm{Cov}[Y_{t-1}, u_t]$ from (E.4) gives,

$$\text{(E.6)} \qquad \mathrm{Var}[Yt] = \frac{\sigma_e^2(1 + \beta\rho)}{(1 - \rho^2)(1 - \beta^2)(1 - \beta\rho)} \,.$$

Finishing up this first proof requires the use of the general results of the least squares estimator,

$$\text{(E.7)} \qquad \mathrm{plim}\ b = \beta + \frac{\mathrm{Cov}[Y_{t-1}, u_t]}{\mathrm{Var}[Y_t]} \,.$$

and replacing $\mathrm{Var}[Y_t]$ with (E.6). The following shows that least squares is inconsistent unless ρ equals zero,

$$\text{(E.8)} \qquad \mathrm{plim}\ b = \beta + \frac{\rho\,(1 - \beta^2)}{(1 + \beta\rho)} \neq \beta \,.$$

For the second proof, let X be a Tx1 matrix of second-period lagged dependent variables (Y_{t-2}). Another way to show equation (E.8) using the general equation,

$$\text{(E.9)} \qquad Y = X\beta + u$$

is

$$\text{(E.10)} \qquad \mathrm{plim}\ b = \beta + \mathrm{plim}\left(\tfrac{1}{n}X`X\right)^{-1} \cdot \mathrm{plim}\left(\tfrac{1}{n}X`u\right) \neq \beta$$

---

same results.

since plim $(\frac{1}{n}X`u) \neq 0$.

To continue, suppose Z_{nxk} exists with the following properties:

$$\text{plim } (\tfrac{1}{n}Z`u) = 0$$

$$\text{plim } (\tfrac{1}{n}Z`X) = Q_{ZX} \qquad \text{a finite, LxK matrix with rank K}$$

$$\text{plim } (\tfrac{1}{n}Z`Z) = Q_{ZZ} \qquad \text{a finite positive definite matrix.}$$

As stated, the Z variables are postulated to be uncorrelated in the limit with the disturbance (u) and to have nonzero cross-products with X.

Next, equation (E.9) is premultiplied by $(\frac{1}{n}Z`)$ to get,

$$\text{(E.11)} \qquad \text{plim } (\tfrac{1}{n}Z`Y) = \text{plim } (\tfrac{1}{n}Z`X)\beta + \text{plim } (\tfrac{1}{n}X`u).$$

Equation (E.11) simplifies to

$$\text{(E.12)} \qquad \text{plim } (\tfrac{1}{n}Z`Y) = \text{plim } (\tfrac{1}{n}Z`X)\beta$$

since plim $(\frac{1}{n}Z`u) = 0$. Rearranging (E.12) gives the least squares estimator using the the second-period lagged dependent variable as an instrument for the first-period lag,

$$\text{(E.13.1)} \qquad \beta_{IV} = \text{plim } (Z`X)^{-1} \cdot \text{plim } (Z`Y)$$

or

$$\text{(E.13.2)} \qquad b_{IV} = (Z`X)^{-1}Z`Y.$$

Through further substitution, the consistency of the instrumented least squares estimator is obtained. Namely, Y in equation (E.13.2) is replaced by (E.9) as followed,

(E.14) $$b_{IV} = (Z'X)^{-1}(Z'X)\beta + (Z'X)^{-1}Z'u$$

$$= \beta + (Z'X)^{-1}Z'u.$$

Then in the limit, equation (E.14) becomes

(E.15) $$\text{plim } b_{IV} = \beta + \text{plim } (\tfrac{1}{n}Z'X)^{-1} \cdot \text{plim } (\tfrac{1}{n}Z'u).$$

Substituting gives,

(E.14.1) $$\text{plim } b = \beta + Q_{ZX}^{-1} \cdot 0$$

or

(E.14.2) $$\text{plim } b = \beta.$$

Appendix F: Developed Countries

The following list of countries, taken from the BEA classification in the "U.S. Direct Investment Abroad," is used in my calculation of developed countries in chapter 2.

Australia	Germany	Norway
Austria	Greece	Portugal
Canada	Ireland	Spain
Belgium	Italy	Sweden
Denmark	Japan	Switzerland
Finland	Luxembourg	Turkey
France	Netherlands	United Kingdom

I excluded New Zealand and South Africa in the calculation of MOFA sales (after 1989) and exports (for all years) because of data limitation. Without a clear definition, I did not included countries under the BEA grouping of "other" Europe for my computation of U.S. exports to the developed countries. Instead, I assume that exports to "other" Europe are insignificant. My assumption may be justified since "other" accounts for only 1.24 percent of MOFA sales in Europe.

Appendix G: Standard Industrial Classification (SIC) Codes

This listing of all Standard Industrial Classification (SIC) codes is available on the University of Washington's website at http://weber.u.washington.edu/~dev/sic.html.

SIC	SIC CODE DESCRIPTION
20	Food And Kindred Products
201	Meat Products
202	Dairy Products
203	Preserved Fruits and Vegetables
204	Grain Mill Products
205	Bakery Products
206	Sugar and Confectionery Products
207	Fats and Oils
208	Beverages
209	Misc. Food and Kindred Products
28	Chemicals And Allied Products
281	Industrial Inorganic Chemicals
282	Plastics Materials and Synthetics
283	Drugs
284	Soap, Cleaners, and Toilet Goods
285	Paints and Allied Products
286	Industrial Organic Chemicals
287	Agricultural Chemicals
289	Miscellaneous Chemical Products
33	Primary Metal Industries
331	Blast Furnace and Basic Steel Products
332	Iron and Steel Foundries
333	Primary Nonferrous Metals
334	Secondary Nonferrous Metals
336	Nonferrous Foundries (castings)
339	Miscellaneous Primary Metal Products
34	Fabricated Metal Products
341	Metal Cans and Shipping Containers
342	Cutlery, Handtools, and Hardware
343	Plumbing and Heating, except Electric
344	Fabricated Structural Metal Products
345	Screw Machine Products, Bolts, Etc.
346	Metal Forgings and Stampings
347	Metal Services, Nec
348	Ordnance and Accessories, Nec
349	Misc. Fabricated Metal Products

35 Industrial Machinery And Equipment
- 351 Engines and Turbines
- 352 Farm and Garden Machinery
- 353 Construction and Related Machinery
- 354 Metalworking Machinery
- 355 Special Industry Machinery
- 356 General Industrial Machinery
- 357 Computer and Office Equipment
- 358 Refrigeration and Service Machinery
- 359 Industrial Machinery, Nec

36 Electronic & Other Electric Equipment
- 361 Electric Distribution Equipment
- 362 Electrical Industrial Apparatus
- 363 Household Appliances
- 364 Electric Lighting and Wiring Equipment
- 365 Household Audio and Video Equipment
- 366 Communications Equipment
- 367 Electronic Components and Accessories
- 369 Misc. Electrical Equipment & Supplies

37 Transportation Equipment
- 371 Motor Vehicles and Equipment
- 372 Aircraft and Parts
- 373 Ship and Boat Building and Repairing
- 374 Railroad Equipment
- 376 Guided Missiles, Space Vehicles, Parts
- 379 Miscellaneous Transportation Equipment