DETERMINANTS OF OUTWARD FDI: ROLE OF TECHNOLOGICAL INTENSITY, SPILLOVERS AND INTANGIBLE ASSETS

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Abstract

This study investigates whether foreign direct investment (FDI) is governed by technological intensity, technology spillovers and intangible asset acquisition motives. The analysis is undertaken for U.S. outward FDI for a sample of developed economies. The results indicate that technological intensity in the host country is a significant determinant of outward FDI, as are other motives, like market access and tariff-jumping. Once the spillover and intangible asset acquisition motives are taken into account, market access motive in outward FDI disappears.

Keywords: R&D Spillovers, Technological Intensity, FDI, Intangible Asset Acquisition.

JEL classification code: F23, O30, O31.

INTRODUCTION

The last twenty years have seen an enormous growth of activity by multinational enterprises (MNEs) as measured by the flows of foreign direct investment (FDI). FDI has grown at a much faster rate than either trade flows or income. The predominant source of the supply of FDI is the advanced industrialized nations. The major single investor is the U.S., controlling about 24% of the world's FDI stock, compared to 49.1% for the 15 EU countries and 6.1 % for Japan.[1] Direct investment undertaken by U.S. multinationals is thus an important characteristic not only of the U.S. economy but also for the world economy as a whole. This is important both to countries that undertake FDI: the home country and the country in which FDI is located known as the host country. The sheer size of FDI can create employment and assets in the host country, and it can improve the balance of payments through exports.

This paper empirically investigates the determinants of U.S. outward FDI for a sample of developed economies using panel data estimation techniques over the period 1982 to 2000. The main objectives of this paper are as follows: (a) How important is technological intensity in the host country in explaining outward FDI? (b) Are MNEs motivated by technology sourcing (spillovers) through FDI, or do they seek to enhance the value of their intangible assets, such as their patented technology? (c) Does there exist a non-linear relationship between spillovers from R&D activities and outward FDI?

The answers to the first and second questions are intrinsically related, as they are linked to the ownership and internalization advantages of the MNE. When a multinational firm sets up a research lab in the host country, it may be motivated first to adapt its products to local market conditions and to provide technological support to the subsidiary. This technology transfer benefits only the host country. Second, the MNE may want to monitor new technology developments in another country in order to "tap" foreign technology. By being in countries with more expertise in a given technological field, the MNE can penetrate other markets at a lower cost of production. The acquisition of technologically advanced firms in the host country or establishing a subsidiary in this country can substantially improve the ability of a firm to learn from and absorb the technology. This can be coined as the "spillover motive" and is related to the second question we investigate. Third, the firm may want to develop the technology in which the host country has a comparative advantage in producing and which may supplement the core technology of the firm.

The second question is concerned with whether MNEs are motivated by acquiring strategic assets, such as increasing the value of their intangible assets, or whether are they interested in asset exploring motives (spillovers). This issue is directly related to the exploitation of intangible assets in foreign markets, which has been coined in the literature as the "internalization advantages" of the MNE.[2] The intangible assets of the MNE may consist of either superior knowledge (for example, the design of a new product) or goodwill (associated with the product quality or a new patented technology). The purpose is to maximize the value from the intangible assets while setting a production facility abroad. The problem of externalities associated with intangible assets requires the MNE to choose between licensing the right to use its know-how to a foreign firm or exploiting it internally by establishing foreign subsidiaries. When the intangible asset of the MNE is very easy or very difficult to transfer, internalization is the most likely outcome. On the other hand, in the presence of incomplete information, the choice between licensing and internalization will depend on the interaction between technology and market variables.[3] If knowledge is transferred to foreign parties through spillovers, the licensee may stop paying the MNE and set up a production facility. The MNE can then license a new partner to set up a new production facility and compete with the former licensee. If a contract that avoids defection is possible, then the MNE can extract all the rent from its intangible assets. However, if defection cannot be avoided, then the rent to the MNE declines due to loss in market power. Under such a situation, it may be worthwhile for the MNE to set up a subsidiary.

Finally, a non-linear relationship is postulated between FDI and spillover R&D measures on the following grounds:

(i) If the MNE is a strong technology leader, its presence is motivated by asset exploitation. However, if it is lagging far behind the industry leader of the host country, its presence is motivated by R&D spillovers. If the difference in the knowledge stock between the two countries is small, the two effects may cancel each other.

(ii) Firms with either very low or very high levels of absorptive capacity may be the least likely to benefit from spillovers, as they either do not have the technological ability or are too similar in their technology to the MNEs to be able to benefit from spillovers.

This paper explores measurement and analytical issues related to the internationalization of technology based on detailed R&D and patent data for the MNEs. These indicators are calculated at the country level for 13 OECD countries where U.S. FDI is mostly concentrated for the period 1982 to 2000. This period is chosen since internationalization of technology (as measured by R&D expenditures by U.S. subsidiaries) has increased more than three fold, and FDI has increased rapidly. These indicators are useful because the relative advantages and drawbacks of each measure can be identified, and the trends of the internationalization of technology can be highlighted.

Empirical studies of the role of spillovers on outward FDI have not provided a uniform answer as to whether this motive plays a role. In view of the above, section 2 provides a critical survey of the existing literature. Section 3 contains a few descriptive statistics relating to outward FDI and its distribution, the country patterns of internationalization of technology, patent based indicators, and R&D based indicators. Section 4 discusses the data, measurement issues and the empirical model used in the country analysis. Section 5 presents and discusses the results of the econometric models used. Section 6 concludes.

EMPIRICAL LITERATURE ON SPILLOVERS AS A MOTIVE FOR FDI

There is a rich body of empirical literature as compared to the relatively limited number of theoretical studies on the spillover effects. The earlier studies[4] usually considered the relationship between FDI and productivity. Spillovers were considered to exist if a positive correlation between productivity and FDI was found. The dependent variable in these models was generally labor productivity, while the explanatory variables were FDI, factor inputs, and concentration ratio. Most of these studies were cross-sectional in nature and were limited to labor productivity in manufacturing for a single country. During the 1990s, research in this area has increased vastly to understand the complex nature of spillovers, such as spillovers from R&D activities and patent citations, as determinants of outward and inward FDI flows. With the advances of time series techniques, the analyses have been conducted to include more manufacturing sectors and countries to understand the determinants of FDI flows. Some of the main studies find evidence of spillovers as a motive for undertaking FDI, and other studies contradict this finding. Following this is an assessment of the empirical literature and the direction in which the present study extends the literature.

(A) Studies that Support the Spillover Hypothesis

As discussed above, most studies on the spillover effect have examined the impact of FDI on domestic firms' productivity growth. A pioneering study by Blomstrom, Kokko and Zejan (1994) examined the spillover hypothesis by testing for determinants of technology transfers. They analyzed how technology imports of foreign firms are related to various industry characteristics. Their hypothesis was that market rivalry and the availability of skilled labor will encourage the MNE to bring more technology to their foreign operations. Using data for Mexican manufacturing firms from 1970 to 1975, foreign firms' technology payments abroad were considered as a proxy for total technology imports, which was the dependent variable. The share of white-collar employees in the labor force and the wage payments made by foreign firms were proxies for availability of skilled labor. The market share of firms was a proxy for local competition. The controls were domestic firms' expenditure on technology, the average license payments by U.S. industries, and the advertising expenditure of Mexican firms. The results showed a significant relationship between technology imports by foreign affiliates and local competitors output growth and labor skills, thus providing strong support for the spillover hypothesis.

Neven and Siotis (1996) provide one of the most extensive empirical analyses of technology sourcing through FDI. The FDI flows among Japan, USA, UK, Germany, France, and Italy were investigated for 8 manufacturing sectors. This sectoral analysis allowed looking at FDI flows from one sector in the home country to another sector in another country. FDI flow was the dependent variable, while R&D intensity of the home and host countries were the independent variables. The paper tests with R&D differences and sums to capture spillover effects and technological rivalry effects. Various host country controls were also used to capture the more traditional motives for undertaking FDI. The results showed that U.S. and Japanese foreign investment are motivated by technology sourcing, while in the case of intra-European FDI, there was no evidence for such a motive. The authors argue that the single European market could be one way of explaining why R&D spillovers are less important among European countries.

Narula and Wakelin (2001) also use macroeconomic data in their study of U.S. outward investment flows in six European countries and Japan. The dependent variable is FDI flows, while the independent variables are country size, labor costs, exports from the U.S. to the host country, the exchange rate and the relative technological indicators measured in terms of the number of patents granted by the U.S. patent office to foreign companies and the U.S. companies. The major results are that determinants of U.S. FDI vary considerably according to the host country. For countries such as the UK and Japan, the technological advantage of the U.S. and the lower relative wages of the host country are the main determinants of U.S. FDI. For Germany, the combination of technological assets of Germany relative to the U.S., lower relative unit labor costs, and past exports are the main determinants influencing FDI. While technology plays an important role in influencing FDI for almost all the countries in the sample, the influence of the technology variables for the home and host country in influencing FDI differs.

Barrell and Pain (1999) examine the determinants of U.S. outward investment activity as a function of agglomeration variables of European countries. The study is based on panel data estimation covering five manufacturing sectors and six countries. R&D activity in the host country is one of the explanatory variables, and it was measured by R&D intensity of an industry in one country relative to the R&D intensity in another country in the same industry. This variable has a positive and significant influence on U.S. FDI in European countries. The study also provides an interesting experiment where competing motives for U.S. FDI are specified for France, UK and Germany. For the UK, low labor costs is counteracted by low R&D intensity of the UK manufacturing industries relative to Germany. For Germany, the reverse holds i.e., initial attraction of high R&D intensity of industries is diminished by the labor cost disadvantage.

Globerman et al. (2000) study the multinational activity of Swedish firms using patent citations as a measure of spillovers. They use data from the Swedish patent applications to understand whether firms source the foreign technologies that are essential for the development of their own innovations. The dependent variable is the number of citations to a country for Swedish patent applications. The explanatory variables are foreign patent stocks, distance, the degree of similarity in production structure, trade flows and foreign direct investment stocks. They find that Swedish multinationals have a higher rate of patent citations from countries where they have invested. Distance has a negative impact on the probability of observing a citation, supporting the existence of R&D spillovers flowing from the host country to the multinational.

(B) Studies that Contradict the Spillover Hypothesis

One of the earliest studies that contradicted evidence for FDI driven by spillovers was Kogut and Chang (1991). They analyzed Japanese FDI in the U.S. with Japanese and U.S. industry characteristics. The dependent variable was the number of Japanese entries in the U.S. industries over the period 1976 to 1987. Both the countries' R&D expenditures as a proportion of sales (R&D intensity) represent the main explanatory variables. The difference between Japanese R&D intensity and U.S. R&D intensity represents the spillover motive if the coefficient is negative, while the motivation is to acquire technological capability abroad if the coefficient is positive. The sum of the two components measures the effect of R&D rivalry on foreign entry decision. The controls of the model were Japanese and U.S. industry concentration, U.S. advertising expenditures as a measure of competitiveness, shipment as a measure of size, and imports and trade restrictions, which measures the tariff-jumping motive for the MNE. The analysis showed no significant motive for R&D spillovers as a motive for foreign entry. The control variables, which were trade restrictions, industry concentration in both countries and R&D intensity for Japan, turned out significant with the correct signs. The authors then split the sample into joint ventures, acquisitions and new manufacturing plants. They found that the R&D difference variable was negative and significant for firms having joint ventures, providing some support to spillovers through FDI by Japanese firms.

Kokko (1994), using data for 230 manufacturing establishments for Mexico during 1970, conducts tests to understand how spillovers are related to various proxies of MNE technology. Value added per worker was the dependent variable, while the various explanatory variables were foreign plants' employment to total employment in each industry measuring foreign presence, the factor intensity variable (capital-labor ratio), the ratio of white-collar to blue-collar workers measuring labor quality, and the Herfindahl index, which was used to measure concentration in each industry. The sample was then divided into two groups, namely the high and low technology groups. The results showed the existence of spillover effects in both groups. However, when the interaction term of FDI and technology gap was included in the model as an explanatory variable, the coefficient of the spillover in the hi-tech group turned out to be insignificant. Based on this result, the author concluded that spillovers do not generally occur in technologically complex industries.

Braconier et al. (2001), using firm and industry level data for Sweden, study whether inward and outward FDI work as channels for R&D spillovers. Total factor productivity is considered as the dependent variable, while the explanatory variables are R&D expenditure of the firm, the spillover variables through outward and inward FDI, the capital intensity of the firm, and time dummies. They find no evidence of inward or outward FDI as channels of R&D spillovers, since neither of them was correlated with total factor productivity. The lack of FDI transmitted R&D spillover is interpreted by the authors to show that countries with higher R&D expenditures gain less from spillovers. This conclusion is very surprising, since other studies have found some presence of international spillovers from R&D, even for OECD countries.

In a recent study, Grunfeld (2000) examines the determinants of foreign ownership in Norway using firm level panel data during the period 1990 to 1996. The foreign ownership shares are regressed on R&D intensity of the host country firm, the industry R&D expenditures, and R&D intensity of the foreign owners apart from other firm-specific controls. The above intensities were used as technological level and competitiveness of firms and industries. The main hypothesis tested is that MNEs are motivated by technology sourcing motives in Norway. This is because if a MNE has established a location abroad to absorb knowledge in the host country, one can expect that the technological level associated with the MNE was relatively low compared to the host. If it was the opposite, the MNE would have less to learn from investing abroad. The paper does not find any support for the spillover motive from the subsidiaries to the MNE. Additionally, MNEs reduced and increased their exposure more frequently in high-technology intensive sectors. This is interpreted by the author that high risks associated with R&D based activities can create large gains and losses for the MNE.

(C) Assessment of the Empirical Literature and Extension

Most of the earlier studies regressed labor productivity on FDI, which implicitly assumes that FDI is caused prior to productivity growth. However, causation can run in both directions.[5] As a result, one could potentially find positive spillovers from FDI even though no spillover occurred. Another problem with these studies is that R&D intensity and trade intensity are not often considered. This can lead to specification bias due to omitted variable problems.

At best, there is mixed evidence of the existence of positive spillovers from R&D activities on FDI flows. It is usually the case that studies based on aggregate data are more supportive of the existence of spillovers. On the other hand, studies based on firm and industry level data generally do not support the existence of spillovers. Due to the complexity of measuring spillovers and data constraints, most studies still focus on examining the relationship between FDI and labor productivity. The present study extends the existing literature by taking into account different technological intensity indicators (both technological input such as R&D intensity and technological output such as patents) to understand their role in outward FDI. The measures of spillovers constructed will help in understanding whether reverse spillovers (from subsidiary to the parent) are also important determinants of outward FDI. The asset acquisition motive (increasing value of the intangible assets) of the MNE is considered as an independent determinant, apart from the spillover and technological intensity motives. In the next section are some stylized facts of U.S. MNEs: their distribution of outward FDI by regions, the trends of internationalization of technology as evident from R&D expenditure of affiliates, and the share of patenting by countries during the last two decades. This descriptive analysis will help in furthering our understanding of the various motives that MNEs use to locate their investment facilities abroad.

STYLIZED FACTS OF U.S. OUTWARD MNE ACTIVITIES

The growth and prominence of U.S. MNEs illustrate the increasing importance of foreign direct investment compared to trade or GDP since the mid 1970s. This process happened during the post-war period, with the U.S. strengthening its technological advantage in contrast to the rest of the industrialized world. The high cost of capital in the U.S. and the low competitive advantage of many countries led to a rapid growth of U.S. FDI activity. The U.S. accounted for almost half of all FDI stocks until the early 1970s. Subsequently, the U.S. share of world FDI has declined, and it was about 25 percent during 1995.

Table 1 illustrates a number of features of U.S. FDI by regions, by developed and developing countries. First, the concentration of U.S. outward FDI flows has declined marginally for the developed countries, from 73.2 percent during 1985 to 69.2 percent during 2000. Among the sample of countries, there has been a strong surge of FDI in the UK[6], from 14 percent during 1985 to almost 19 percent during 2000. Shares of U.S. FDI in Japan have almost doubled over the period 1980 to 2000. Comparing U.S. FDI by regions, we find that the share of U.S. FDI has increased substantially for European, Latin American countries, and other selected western hemisphere countries over the period 1985 to 2000 (comparing columns 2 and 5). This trend can be attributed to an increase in FDI in the UK, Italy and Netherlands in Europe, and similar trends in Mexico and Brazil during the 1990s. Among the other findings of interest is that the share of U.S. outward FDI to countries in Africa and the Middle East and to Canada has declined over the sample period. The reason for the decline in share of U.S. FDI in Canada needs some explanation. Although U.S. investment in Canadian plants has actually increased in absolute terms, exports from the U.S. have grown at a faster rate after formation of NAFTA in 1994. The proportion of U.S. FDI in the natural resources sector has declined significantly, and there has been a decreased commitment by U.S. firms in this sector. Also, U.S. investment in general-purpose technologies (such as computers, communications, and the electrical industry) has declined in Canada, since Canadian companies are significantly less innovative than their counterparts in the U.S. This decline in R&D intensity in Canada has caused many U.S. businesses to move out of Canada and to invest in Europe and Japan. Turning to U.S. FDI in Asia and the Pacific region, we find that the share has been relatively constant during the last two decades. The relative decline in FDI during the late 1990s can be attributed to the currency crisis in Asia and the slowdown in macroeconomic fundamentals, such as GDP growth and export growth.

Table 2 shows R&D expenditures undertaken by majority owned foreign affiliates in various countries, including the countries for the regression analysis in the sample. R&D expenditures by U.S. multinational companies abroad have increased more than 5.7 times[7] during the past two decades. Most of the R&D abroad is mainly concentrated in developed countries such as France, Germany, the UK and Japan. The industrialized countries where the share of R&D increased over the period 1982-2000 are Japan, Sweden and Ireland, although the major recipient country of U.S. R&D expenditures is the UK. Canada's share of inward R&D expenditures has declined over this period. This may be because Canada has lower private sector R&D spending as a share of GDP compared to the U.S., and Canada is significantly slower than its U.S. counterparts at adopting leading edge methods and processes. Among the emerging market countries, Singapore, Mexico and Brazil are the largest recipients of U.S. R&D. R&D facilities in Mexico and Brazil are concentrated in auto parts, while in Singapore R&D facilities are concentrated in the electronics and communication industry.

From table 3, it is evident that most R&D expenditures abroad were concentrated in chemicals, motor vehicles, and industrial machinery. The intensity of the globalization trend in R&D is measured by the ratio of R&D abroad to domestic R&D spending. This trend in R&D facilities across industries shows that some U.S. industries require R&D and production facilities to be located abroad, such as motor vehicles and chemicals in Europe. This is not only to develop products for local markets, but also to take advantage of the technological intensity to gain knowledge in countries such as Germany and the UK (the chemical industry in Germany and the pharmaceutical industry in the UK).

Table 4 shows the number of U.S. R&D facilities abroad for each country. As evident from the table, U.S. R&D investments abroad continue to concentrate primarily in developed economies (almost 81 percent of R&D facilities abroad are located in developed economies). Recently, a number of industrializing economies have emerged as hosts to R&D investments by U.S. MNEs. India and Singapore host Microsoft and Oracle. Singapore hosts Digital Electric

Corporation, Compaq and Black and Decker for the development of hardware, software and household electrical appliances. Cisco is developing semiconductors and software development in Taiwan. These trends show the presence of supply oriented motives in driving R&D investments namely, the availability of high-skilled R&D personnel, development of new products for exports in other markets, and monitoring technological developments abroad more keenly.

Table 5 shows the number of patents granted by the U.S. patent office to inventors in countries in the sample. Considering patenting activity as a measure of technological change is advantageous, because it is a measure of technological output. It can be broken into greater statistical detail by geographic location and technological sectors. 159,428 U.S. patents were granted to inventors in 1999. Of the total, U.S. inventors received almost 84,000 patents, which is approximately 53 percent of the total. The foreign share of U.S. patents during 1999 was highly concentrated in the following six countries: Japan, UK, Canada, France, Germany, and Italy. Japanese inventors received the largest number of U.S. patents (about 19.5 percent), followed by Germany (almost 6 percent) and Canada (2.5 percent). It is important to note that although the absolute number of patents granted to inventors from developed economies has increased over time, the share of patents granted to inventors from these countries has shown a declining trend, with the exception of Canada.

EMPIRICAL MODEL AND ESTIMATION ISSUES

The major aim of this paper is to understand the role of technological intensity indicators (both technological input such as R&D intensity and technological output such as patents) in outward FDI. Technological intensity is important, since foreign owned firms are attracted to industries that display a highly developed technological base, because such industries hold important knowledge source. The role of reverse spillovers from the subsidiary to the parent is also taken into account as an important determinant of outward FDI. Spillovers from the subsidiary to the parent can be an important determinant as it relates to internal knowledge management within the MNE. Better mechanisms of transferring know-how from the subsidiary to the parent increase the profitability of the MNE and induce it to undertake more FDI. However, if there is presence of "dissipation effects" within the host country and transfer of know-how goes to a local firm instead to the parent due to competition effects, the incentive to undertake FDI can decline. Hence, spillovers from the subsidiary to the parent can have an ambiguous impact on the decision to undertake outward FDI. Furthermore, the asset acquisition motive[8] (increasing the value of the intangible assets) of the MNE is considered as an independent determinant apart from the spillover motive. A persistent finding in the literature is that increasing the value of intangible assets allows a firm to engage in direct investment abroad by transferring the technological assets to new markets. The intangible assets are closely related to "core competencies" of a firm, since they are usually non-physical in nature and are capable of producing economic benefits in the future. In the next sub-section, various motives and the variables used for this study are explained.

Variables and measurement issues

The variables[9] and their measurement are defined below:

Dependent Variable:

The dependent variable is U.S. direct investment (ε)[10] abroad on an historical cost basis.[11] Other methods for calculating U.S. direct investment abroad consist of current cost and market value estimates. The current cost estimates the value of the U.S. and foreign parents' shares of their affiliates investment in plant and equipment, using the current cost of capital equipment; in land using general price indices; and in inventories, using estimates of their replacement cost. The market value estimate considers only the equity portion of direct investment, using indices of stock market prices. As the historical cost estimates are not adjusted to take into account current costs of tangible assets or the market value of firms, the estimates on this valuation basis are less than the current cost and market value estimates. Since direct investment position by country and industry details is prepared only on an historical cost basis, the present study uses this as a measure of direct investment abroad.

Controls:

(A) Demand related variables (a):

Factors such as market size and per capita income of the host country are important determinants in MNEs location decisions. This is because host countries with a larger market size and faster economic growth will provide better opportunities for enterprises to exploit their ownership advantages and create possibilities for economies of scale. Thus, we expect the coefficient of this variable to be positive. The various measures to control for market size are real GDP in 1990 millions of U.S. dollars and population in millions, while real GDP per capita is a measure of average productivity of the host country.

(B) Cost factors (W):

These relate to costs of production, including wage costs and transport costs. This variable is measured by taking the difference of unit labor cost index in the host country with that of the home country in U.S. dollars. Cost factors can be an important determinant of multinational activity if different parts of the production process have different input requirements. Since input prices can vary across countries, it may be profitable to split production by undertaking labor-intensive activities in a labor abundant economy. The theoretical argument of this factor as a determinant of outward FDI comes from Helpman and Krugman (1985). The main arguments are that free trade in goods will bring about the international equalization of factor prices, provided the countries' relative endowments of the two factors are not too different. In such a situation, there is no incentive for multinational activity. However, if the relative endowments are different, then trade does not equalize factor prices. Then it is profitable for firms to divide activities by putting the capital-intensive part in the headquarters, while moving the production operations in the labor abundant economy. Empirical studies have found mixed results for cost variables, especially for FDI between industrialized nations.[12]

(C) Trade related cost factors (τ):

The impact of trade cost as a determinant of FDI has been examined empirically, mainly during the late 1990s. The results are at best mixed. Brainard (1997) analyzed inward and outward U.S. investments in 1989 using industry specific data. She finds subsidiary sales to be greater when transport costs and trade barriers in the host country are higher, suggesting that tariff-jumping motives are an important determinant of multinational activity. Recently, Hanson et al. (2001) undertook an empirical analysis on U.S. outward investments using a similar approach to Brainard (1997), but with a panel of U.S. outward investments using industry specific data and several investment years. They find that subsidiary sales are discouraged by trade costs. The result may hold, since higher barriers raise the cost of importing intermediate inputs, thus raising price of goods in the international market. The bound average tariff rates for the OECD countries are obtained from the tariff and trade database of the OECD, and are used in this study as a measure of trade related cost factor.

Explanatory Variables of Interest:

(D) Technological Intensity (¯R¯):

Foreign owned firms are attracted to industries that display a highly developed technological base in the host country. Such industries are important knowledge sources to the MNE, which recognize that serving the foreign market through FDI is more profitable than serving it through exports. Several survey based studies[13] have shown an increased evidence of technology sourcing as a motive for FDI during the 1990s, and it is important to examine this motive in our empirical work with recent data. The various measures that are considered taking into account both home and host countries' technological intensity are as follows:

(i) Ratio of R&D expenditure to GDP of the host country (expressed in percentage).

(ii) Ratio of R&D expenditure to GDP of the U.S. (expressed in percentage).

(iii) Difference in R&D stock: Measured as the difference between R&D stock of the host country (in millions of U.S. dollars) and the U.S., and divided by the R&D personnel of the host country. This measure has been incorporated following Kogut and Chang (1991). To convert R&D expenditures to R&D stock, the data are first converted into millions of U.S. dollars using the PPP exchange rate. The perpetual inventory method is then applied to construct R&D stocks on the assumption that

$$R_t = (1-\delta) R_{t-1} + X_{t-1} \text{ for } t = 2,\ldots\ldots,19$$

$$R_1 = \left(\frac{X_1}{g+\delta} \right) \quad (1)$$

The country subscript has been suppressed. X denotes R&D expenditures, while R denotes R&D stock. The rate of depreciation of R&D stocks, δ, is set at 0.1 in line with the existing literature.[14] g denotes the average growth rate of R&D expenditure over the period 1982 to 2000.

The subtraction of U.S. R&D stocks from that of the host country represents the push and pull factor of R&D on FDI. If this coefficient is positive, it implies that foreign R&D intensity pulls more U.S. FDI, i.e. foreign investment is driven by technology sourcing motives.

(iv) Sum of R&D stock: Measured as the sum of the R&D stock of the U.S. and the host country. It is an indicator of overall degree of technological intensity and rivalry. This measure is deflated by the total R&D personnel of the host country.

(v) Ratio of R&D expenditure of affiliates to gross domestic expenditure of R&D (expressed in percentage): This measure of technological intensity shows the proportion that subsidiaries spend on R&D as a proportion of total R&D expenditure in the country. This indicator shows the internalization of R&D in the host country.

(vi) Patents granted to host country innovators and the U.S. innovators by the U.S. patent office: These are the patents granted by U.S. patent office to firms in other countries. This variable measures not only the technological level of the country, but also technological advantages of the firms within the country. This study is more comprehensive than previous ones, since it includes not only proxies for innovation inputs (such as R&D expenditures and R&D intensities), but also incorporates output measures from the innovation process, such as patenting.

(E) Spillover Measures (α):

There are essentially two kinds of spillovers created through inward FDI: technological and pecuniary. Technological spillovers can arise for example, if inward investment by MNEs enables local firms to upgrade their technology. Spillovers could be direct, from one firm to another, or could be indirect through the labor market. In either case, the greater the technological gap between the local firm and the MNE, the higher the likelihood of positive spillovers from inward FDI. On the other hand, pecuniary spillovers arise when firms are not able to capture the entire surplus from market transactions. As pecuniary externalities are very difficult to measure, this paper concentrates on measuring technological externalities utilizing two measures. The first measure utilizes labor market information in constructing spillovers from the subsidiary to the entire economy, while the second measure uses bilateral export intensity between the host country and U.S. to determine spillovers originating through trade from the subsidiary to the MNE. Following Braconier et al (2001), a similar measure of R&D spillovers through inward FDI is constructed as follows: Let L_{kj} denote employment in affiliates of U.S. MNEs in country *j*, let L_j denote the total employment in country *j*, and let R_j denote the R&D expenditure of affiliates in country j. Then inward spillovers is defined as:

$$IS_j = \left(\frac{L_{kj}}{L_j} \right) R_j \qquad (2)$$

IS_j is a measure of inward spillovers. It is measured as the ratio of employment originating in affiliates of U.S. MNEs to total employment in the country, multiplied by the affiliates R&D expenditures. This measure shows how spillovers can originate from the affiliates of U.S. MNEs to the rest of the host country. The next measure of spillover R&D takes into account bilateral export intensity as a weight between the host country and the U.S. Let γ_{ji} be the elements of a 13 * 13 matrix of the total bilateral exports in goods and services from country *j* to country *i* as a proportion of total exports to all the 13 other countries in the sample (bilateral trade intensity). Let R_i^a denote the R&D expenditure undertaken by affiliates of U.S. MNEs. Then the spillover from the subsidiary to the parent R^p (U.S. parent) is given by

$$R^p = \sum_i \gamma_{ji} R_i^a \qquad \text{with} \quad \gamma_{jj} = 0 \tag{3}$$

The dimension of R_i^a is 13*1. R^p denotes the spillovers occurring from the *j*th country's subsidiary to the parent firm.

The squared spillovers variables are constructed to understand whether a non-linear relationship exists between spillovers from R&D activities and outward FDI. One rationale for this non-linear relationship stems from the fact that at low level of spillovers, MNEs invest less in the host country. At high levels of spillovers, firms can gain more from the subsidiary, and thus invest more in the host country. They are defined as follows:

$$IS_j^2 = \left(\frac{L_{kj}}{L_j} \right) R_j^2 \tag{4}$$

and $$R^{p2} = \sum_i \gamma_{ji} R_i^{a\,2} \tag{5}$$

(F) Intangible Asset Acquisition Motive (Z):

A persistent finding in the literature is that increasing the value of intangible assets allows a firm to engage in direct investment abroad by transferring the technological assets to new markets. An intangible asset represents flow of future income that can be earned from or attributed to it. The intangible assets are closely related to "core competencies" of a firm, since they are usually non-physical in nature and are capable of producing economic benefits in the future. Since many businesses are increasingly deriving their profits from intellectual property, which includes patents, copyrights, brands and trademarks, the valuation of intellectual property (IP) is increasingly gaining importance. There are three main approaches in identifying the value of IP based assets: (i) the cost approach (ii) the market value approach, and (iii) the economic approach. Within the economic approach, there are mainly two methodologies in the valuation of intangible assets:(a) the life cycle cost approach and (b) the royalty approach. It is acknowledged that an economic approach would provide a preferable measure of valuing intangible assets. The royalty method is used in the present study, since the BEA does not collect separate data on royalties and licensing fees. Since aggregate royalties and licensing fees received for each country are the only available data from the BEA, we use the actual royalties and licensing fees received as the measure of value of intangible assets. Whenever the actual royalties and licensing fees are not available (for example, for the years 1982 to 1985), we utilize the present value approach with a discount rate of 10 percent to calculate the royalty and licensing fees as follows:

$$Z_t = \sum_{i=1}^{4} (Z_{t+i} / (1+r)^i \qquad (6)$$

The 10 percent discount rate is chosen since it is the convention in the literature, and the predicted royalty and licensing fees for the entire period with a discount rate of 10 percent approximates the actual Z. The problem measuring the asset acquisition motive is that the aggregate royalties and licensing fees does not differentiate between each component[15] (royalties are usually paid for patents or copyrights, whereas licensing fees are paid by the licensee to the licensor for a certain period of time for the use of the technology). In the future, more detailed patent data by technology class or by sectors will provide further insight into the nature of technology being transferred. It will be possible, for example, to trace the royalties earned from an existing patent. At the same time, data on individual licensing arrangements between U.S.

firms and foreign parties will help us determine the licensing fees by technology class or even by country, which will help us in understanding the nature of technology transfer.

(G) External Factors: Exports (E):

We also control for intra-firm exports to understand how foreign markets are served, i.e., whether firms enter a market initially through exports before undertaking FDI. U.S. exports to majority owned foreign affiliates in millions of U.S. dollars are deflated by the export price index (1990=100) and lagged by one time period. The existing empirical evidence on the relationship between exports and FDI is mixed and depends on whether the MNE is vertically or horizontally integrated. Cross-sectional studies (such as Lipsey and Weiss, 1981) with detailed firm and industry level data on the activities of U.S. and Swedish multinationals find existence of a complementary relationship between exports and FDI. In contrast, Svensson (1996) and Blake and Pain (1994), using longer time series data for Sweden and the UK, find outward investment to have declined with export performance over time, showing that substitutability between exports and FDI are at play. On balance, the evidence from cross-section and panel studies with limited time dimension suggests that exports and FDI are complements, while studies that use a greater time dimension obtain stronger evidence that the two are substitutes. Thus, in the determinants of FDI, it is important to control for exports.

Empirical model

To answer the first question of how important technological intensity is in determining outward FDI, we apply the following model using both home and host country characteristics:

$$\ln \varepsilon_{USj,t} = a + b_1 \ln a_{j,t} + b_2 \ln(GDPCAP_{j,t}) + b_3 \ln \bar{R}_{jt} + b_4 (ULC_{j,USt}) + b_5 \ln \tau_{j,t} + b_6 \ln E_{USj,t-1} + \xi_t \quad (7)$$

for t= 1,…19 and the subscripts US and *j* are for the U.S. and the host country j. Thirteen countries are considered in the sample: Australia, Belgium, Canada, France, Germany, Ireland, Italy, Japan, Netherlands, Spain, Sweden, Switzerland and the UK. The choice of countries was motivated by detailed data on R&D expenditures and patents, and by the fact that U.S. investment is mainly concentrated in these industrialized nations. The time period chosen is from 1982 to 2000. The variables are defined in the previous section. a_j denotes the demand in the host country, and is proxied by GDP in millions of 1990 U.S. dollars and population is in millions. GDPCAP shows how FDI is affected by variation in average level of productivity of the host country. This variable (GDPCAP) also captures whether FDI is usually directed toward high productive economies. To check the robustness of the regressions, various proxies for technological intensity (both technological inputs and outputs) for both the home country and host country are considered in this paper. They are denoted by the variable $\bar{R}$. The difference in relative unit labor costs ($ULC_{j,USt}$) between the host country and the U.S. are included in the model to indicate the cost advantages in the host country relative to the home country. If lower costs are a motivating factor for FDI, this will result in a negative coefficient on the relative unit cost variable.

τ_j denotes the tariff-jumping motive as a determinant of outward FDI. Again, there is mixed empirical evidence whether this motive plays a major role in outward FDI. If trade related costs are important, then we expect this coefficient to be positive. $E_{USj,t-1}$ denotes the lagged exports from the U.S. to the majority owned foreign affiliates, and is included in this model to understand how foreign markets are served. In other words, if exports precede FDI, then the two forms of entry are substitutable, and we can expect a positive coefficient on the export variable.

Data for each country are available on an annual basis for the period 1982 to 2000, i.e. 19 years, giving a total of 247 observations in the panel. The variables have been transformed to natural logarithms in line with the existing literature.[16]

To answer the second question, whether MNEs are motivated by technology sourcing (spillovers) through FDI or if they seek to enhance the value of their intangible assets, such as from their patented technology, equation (7) is modified to incorporate the role of spillovers and the asset acquisition motive (Z) of the firm. The following equation is then estimated:

$$\ln \varepsilon_{USj,t} = a + b_1 \ln a_{j,t} + b_2 \ln(GDPCAP_{j,t}) + b_3 \ln (IS_j \text{ or } R^p) + b_4 (ULC_{j,USt}) + b_5 \ln \tau_{j,t} + b_6 \ln E_{USj,t-1} + b_7 \ln Z_j + \xi_t \quad (8)$$

b_3 can be either positive or negative. If spillovers from the subsidiary to the parent result in dissipation effects where competing local firms gain more than the parent, it can affect the profitability of the parent and thus reduce the incentive to undertake FDI. This will result in b_3 being negative. Conversely, if the cost of both the parent and the subsidiary reduce as spillovers grow, this can increase profits for both firms, and the incentive to undertake FDI increases. We also expect the coefficient of the intangible asset acquisition to be positive, since increasing the value of intangible assets of the firm leads to internalization advantages and increases the incentive to undertake more FDI.

To address the final question whether there exists a non-linear relationship between spillovers from R&D activities and outward FDI, equation (8) is modified as follows:

$$\ln \varepsilon_{USj,t} = a + b_1 \ln a_{j,t} + b_2 \ln(GDPCAP_{j,t}) + b_3 \ln (IS_j \text{ or } R^p) + b_4 \ln (IS_j \text{ or } R^p)^2 + b_5 (ULC_{j,USt}) + b_6 \ln \tau_{j,t} + b_7 \ln E_{USj,t-1} + \xi_t \quad (9)$$

The rationale for this quadratic relationship takes into account the idea that firms with either very low or very high levels of absorptive capacity may be least likely to benefit from spillovers, as they either do not have the technological ability or are too similar in their technology to the MNEs to benefit from spillovers. Setting $b_4 = 0$ implies that the degree of spillovers either increases or decreases monotonically with absorptive capacity. The quadratic specification is more flexible in that it allows the rate at which spillovers affect FDI to vary with absorptive capacity. For example, with $b_3>0$ and $b_4<0$, the initially positive impact of spillovers on FDI will start to diminish once absorptive capacity gets past the critical level (or turning point) IS_j or $R^p = -(b_3/2b_4)$.

RESULTS OF THE MODEL

We initially treated the data as a panel and estimated with fixed effect estimation technique with no cross-section weighting. The fixed effect estimation allows us to determine separate intercepts estimated for each pool member. The problem with this approach is that it gives all observations in the cross-section equal weight. This model was then tested with a generalized least squares model with common coefficient of the intercept for all countries, but with cross-section weights. The advantage of this approach is that it takes all the weights in the preliminary regression as equal and then applies to a weighted least squares in the second round.

$$b = \Big(\sum_i (1/s_i^2)\, X_i'\, X_i\Big)^{-1} \sum_i (1/s_i^2)\, X_i'\, \varepsilon_i \qquad (10)$$

$$\text{and } s_i^2 = (\xi_i'\, \xi_i / n_i) \qquad (11)$$

The vector b corrects for the OLS standard errors using the squared inverse of the variance of the residuals in the first stage of the regressions.[17] Vector X denotes the explanatory variables in equation (7). This method of imposing common coefficient of the intercept term with cross-section weighting corrected for potential heteroskedasticity across the cross-section, and it produced consistent estimates by reducing the sum-squared errors. The likelihood ratio test[18] of the model with fixed effects was tested against the common coefficient model with cross-section weights, and the former model was rejected.

Role of technological intensity in outward FDI

Tables 6 and 7 present the results of the model, showing the relative importance of the different technological intensity indicators on outward FDI. A time dummy is also included to take into account the variation of FDI over time for the sample of countries. Table 6 presents the results with GDP in millions of 1990 U.S. dollars terms, while table 7 presents the results with population in millions as measures of market size, respectively. The results of both the tables are consistent and can be summarized by looking at the estimates based on the pooled data.

In general, the technological intensity variables turn out not to be significant, except for the ratio of R&D expenditure to GDP of the host country (column 1) and relative patenting. The R&D intensity of the host country relative to the U.S. is a driver behind outward FDI. The coefficient of the sum of R&D stock is positive and not significant, while that of the difference of the R&D stock variable has a negative sign and is not significant (columns 3 and 4 of Tables 6 and 7 respectively). This possibly indicates that foreign investment is drawn neither by technology outsourcing motives nor by technological rivalry, but by traditional country specific advantages, such as the overall R&D intensity in specific sectors. In other words, spillover from the parent to the subsidiary may not be a driving force for outward FDI. The parent may fear a loss of competitiveness due to its technological secrets being leaked to a local competitor, thus reducing ownership advantages. Since the measure of technological output, patenting in the host country and in the U.S., have opposite signs, we test for the hypothesis of equal and opposite coefficients. The hypothesis was not rejected (as evident from the Wald Statistic in Tables 6 and 7). Thus we use a relative patenting variable (column 5, defined as the ratio of patents granted to foreigners to the patents granted to the U.S. inventors by the U.S. patent office). This coefficient turns out to be positive and highly significant, suggesting that innovative activity in the host country relative to the U.S. is a driver behind FDI. In general, it appears that country-specific technological advantage is one of the important determinants in outward FDI.

The coefficients on the market size variables (GDP in 1990 U.S. dollars and population in millions) are generally positive and significant as expected. However, after controlling for market size, U.S. firms are not attracted to higher average productive economies. This suggests that the market access motive affects the U.S. MNE's decision to invest abroad and to adopt themselves to foreign market conditions, such as establishing subsidiaries to serve foreign markets through exports.

The coefficient of the relative unit cost variable (ULC) is negative and not significant. U.S. MNEs are not generally motivated by the lower relative cost of the host country, since there are no substantial differences in the relative cost between U.S. employees and foreign employees for the sample of countries chosen. This result is consistent with other authors[19], which suggests that U.S. investment in other developed economies is motivated by factors other than labor cost considerations.

The trade cost measure, as proxied by the average bounded tariff rate (τ), turns out to be positive and highly significant, suggesting that U.S. MNEs are influenced by tariff-jumping strategies. The rationale for this result is that as the cost of trade increases beyond a certain limit, it imposes a cost to the MNE to serve the foreign market through exports. Thus, it becomes more profitable to serve the foreign market through direct investment.

The relationship between lagged exports and FDI deserves attention in this model. The coefficient turns out to be positive and significant, contradicting earlier studies, such as Lipsey and Weiss (1981). The positive coefficient indicates that foreign markets are initially served through exports. However, as trade related and other non-trade related costs increase, it becomes no longer profitable to serve the foreign market through exports. Instead, direct investment becomes the primary way of serving foreign markets. This is consistent with horizontal FDI, since this form of FDI usually substitutes for trade, as parent firms replace exports with local production. The motive is to improve the firm's competitive position in the host country's market. The time dummy is positive and highly significant, suggesting that FDI has become the main channel in serving foreign markets over time.

Spillover or asset acquisition motive: which one is dominant?

Recent investigation by Kummerle (1999b) finds that FDI is motivated by both "home base exploiting (HBE)" and "home base augmenting" motives. In other words, a 'revealed technological advantage (RTA)' index analogous to revealed comparative advantage in trade is postulated where the home and the host countries can be divided into four categories of technological activity. If the home country (where the multinational is present) is relatively weak in RTA, then spillover motives dominate. If the home country is strong in RTA relative to the host country, then the asset acquisition motive becomes dominant. If both the home and the host country are relatively strong in RTA (RTA>1), then spillovers and asset acquisition motives are both prevalent, and MNEs are motivated by strategic asset seeking behavior. If both the home and host country are weak in technology, then FDI is not motivated by technology. This may be the case where southern MNEs try to establish a subsidiary in another developing country for gaining greater market access. The existing literature has not investigated this issue in sufficient details[20], thus we explore the hypothesis whether both spillovers and asset acquisition motives are important determinants of locating investment facilities abroad by U.S. MNEs. This is important since U.S. MNEs may be motivated to gain technological advantage, as in the German chemical industry, or to acquire strategic assets in these countries.

Two measures of spillovers are considered in the present study. The first measures utilizes labor market information in constructing spillovers from the subsidiary to the entire economy, while the second measures spillovers originating through trade from the subsidiary to the parent using bilateral export intensity between the host country and the U.S. We test equation (8) and carry out Wald statistics to see the joint significance of the coefficients, i.e., $b_3 = 0$ and $b_7 = 0$. We test whether both spillover and intangible asset acquisition motives are prevalent in outward FDI.

Table 8 presents the results of the relative effects of spillovers from the subsidiary to the parent and the intangible asset acquisition motives in determining outward FDI. From equations (1) and (2), we find mixed evidence of the spillover motive over the asset acquisition motive for the MNE. The restriction that spillover and asset acquisition motives are not present simultaneously was rejected against the alternative that one or both motives were present, using the Wald statistic ($\chi^2_2 = 9.21$). From this specification, we find that the asset acquisition motive dominates over the spillover motives. In the first equation, spillovers from employment in the affiliates and intangible asset acquisition are both prevalent motives. In the second equation we find that trade related spillovers are not present from the subsidiary to the parent, only the asset acquisition motive dominates. Another interesting feature of the model is that once the asset acquisition and the spillover motives are taken into account, the traditional explanation of market size effects on FDI vanishes. This may be because U.S. MNEs seek market access to other developing countries, and the market access motive is not the dominating motive in locating investment facilities in developed countries. On the contrary, asset acquisition motives (possibly through mergers and acquisitions) may be the dominating motive for U.S. MNEs to locate investment facilities in these developed economies.

Non-linear relationship between spillovers and FDI

Finally, we undertake estimation of equation (9) to find whether there is a presence of a non-linear relationship between spillovers from R&D activity and the incentive to undertake FDI by MNEs. The rationale for this quadratic relationship takes into account the idea that firms with either very low or very high levels of absorptive capacity may be least likely to benefit from spillovers. They either do not have the technological ability or are too similar in their technology to the MNEs to benefit from spillovers. Thus, we can expect if b_3 is positive, then b_4 will be negative, and if b_3 is negative then b_4 will be positive. In the former case, the initial positive impact of spillovers on FDI will start to diminish once absorptive capacity gets past the critical level. In the latter case, lower level of spillovers generated by the host country from R&D activities does not provide incentive for the MNE to undertake more FDI. As the degree of spillovers increases beyond a critical point, the opposite effect takes place. Thus at higher level of spillovers from the host country, the MNE has the incentive to undertake more FDI.

Table 9 presents the results with spillovers from employment and trade as motives for undertaking FDI. Equation (1) shows the results of spillovers resulting from employment of the affiliates, while equation (2) shows results of spillovers originating from trade from the affiliate to the parent. At low levels of employment in the affiliates, R&D resources generate increasing returns to FDI, and the spillover coefficient from employment is significant. At high levels of employment in the affiliates, R&D resources in the host country have a negative impact on the incentive to undertake FDI. A rationale for this result is that initially, with fewer employees, each employee has more R&D resources to work with. Beyond a critical level of employment, each employee has fewer resources to work with, and the initial positive impact on FDI fades. In contrast, the relationship between spillovers from trade activities and FDI is at work. If the host country does not significantly trade prior to the MNE undertaking investment activities, spillovers have negative impact on the incentive to undertake more investment activity. This is because the MNE perceives that undertaking FDI in the host country is not profitable. If the initial level of spillovers from trade activities is high, the MNE assumes there are significant localized spillovers from the firms in the host country, which provides an incentive to undertake FDI in the future. This provides support for the hypothesis that at low levels of spillovers (it is conceivable that at low levels of spillovers, the technology gap between the home and host country is very large), the incentive to undertake investment in the host country is small. If spillovers from R&D activities pass a critical threshold value ($0.897 = -(b_3/2b_4)$), we find that the MNE has incentive to undertake FDI in the host country. We also find the lagged exports and time dummy coefficients to be positive and significant, suggesting that initially the MNE serves the foreign market through exports before undertaking FDI. Once spillover motives are taken into account, the tariff-jumping motive disappears (the coefficient of the tariff variable is no longer significant). This may be because once the MNE realizes that spillovers from R&D activities in the host country is sufficiently high, the initial trade barriers can make local sales more attractive than exports (possibly because the cost of intermediate inputs increases). Thus, tariff-jumping motive may no longer be the dominating factor in undertaking investment in the host country.

Robustness of the results

We check the robustness of our results (tables 6 and 7) by changing the dependent variable to FDI per worker in equation (7) and examine (as in tables 6 and 7), the relative importance of the different technological intensity indicators in outward FDI.

Table 10 presents the results with GDP per capita in 1990 U.S. dollar terms as a measure of market size. In general, the technological intensity variables turn out not to be significant as before. The only difference in this case is that R&D intensity of the affiliates turns out to be significant apart from the ratio of R&D expenditures to GDP of the host country. Additionally, we find that the coefficients of the sum of R&D stock and the difference of R&D stock between the host country and the U.S. in equations (3) and (4) of table 10 to have equal and opposite coefficients. We thus undertake a Wald test to determine if that is the case. We find support to the hypothesis that the sum of R&D stock and the difference of the R&D stock effects cancel each other. This suggests that technological rivalry and push and pull factors of R&D on outward FDI do not matter.

The coefficient of the market size variable (GDP per capita in millions of 1990 U.S. dollars) is positive and highly significant as before, implying that greater market size helps in generating economies of scale and the demand for new technology, and induces greater foreign direct investment to the host country. The coefficient of the relative unit cost variable (ULC) is generally negative and not significant as before. Thus, U.S. MNEs are usually not motivated by the lower relative unit labor cost of the host country, since there is no substantial differences in the relative cost between U.S. and foreign employees for the sample of countries chosen. This result is consistent with the fact that U.S. investment in developed economies is motivated by factors other than labor cost considerations.

The trade cost measure as proxied by the average bounded tariff rate (τ) turns out to be positive and generally significant (except in equations (2) and (5)).[21] The coefficient of lagged exports turns out to be positive and significant as before, indicating that foreign markets are initially served through exports and later through FDI. This result is consistent with horizontal

FDI, as the MNE substitutes FDI for trade. The motive is to gain market access from the host country.

Finally, the time dummy is positive and highly significant, suggesting that FDI has increased over time for U.S. MNEs, and is the main mode of serving the markets in these advanced developed economies. Overall, the results are extremely robust to specification changes as evident from above.

CONCLUSION

This paper aims at overcoming several shortcomings of the existing empirical research on the relationship between the technological intensity of the host country, the technological externalities from R&D activities of the MNE and the affiliates on outward FDI. First, broader measures of the technological intensity of the host country are constructed (both technological input measures and technological output measures) in order to understand whether technological intensity in the host country alone matters for undertaking FDI. Second, we address which motive dominates: the spillover or asset acquisition motive for the MNE undertaking FDI. Finally, we address whether there is a presence of non-linear relationship between spillovers from R&D activities and outward FDI.

Many interesting results have emerged from the models used. First, in understanding the role of technological intensity as a motive for undertaking FDI, we find innovative activity in the host country is a driver behind FDI. In general, it appears that the ratio of R&D expenditure to GDP and R&D expenditures of affiliates are the major determinants in outward FDI. Market size has generally a positive and significant impact on outward FDI, while the relative unit labor cost is generally negative and not significant. Tariff-jumping is still prevalent among U.S. MNEs in other developed countries. Additionally, we find that foreign markets are initially served through exports and later through direct investment. This implies that serving the foreign market through exports and FDI is substitutable in the sample of developed countries. This is also corroborated by the fact that the coefficient on the tariff variable turns out to be positive and highly significant. Overall, our results point more to "horizontal" FDI rather than "vertical" FDI as motives for undertaking investment abroad. Undertaking the robustness tests changing FDI per worker as the dependent variable confirms the above general findings.

Second, the intangible asset acquisition motive is another primary motive for locating investment facilities abroad. This result is consistent with the idea that acquisition of intangible assets allows a firm to engage in direct investment overseas by transferring these assets to new markets. Another interesting result is that once asset acquisition and the spillover motives are taken into account, the traditional explanation of market size effects on FDI disappears. This is because U.S. MNEs may seek market access to other developing countries, and the market access motive may not be the only dominating motive in locating investment facilities. On the contrary, asset acquisition motives (possibly through mergers and acquisitions) may be the dominating motive for U.S. MNEs to locate investment facilities in these developed economies.

Finally, we find evidence of a non-linear relationship between spillovers from R&D activity and the incentive to undertake FDI by MNEs, consistent with the idea that firms with either very low or very high levels of absorptive capacity may be least likely to benefit from spillovers. They either do not have the technological ability or are too similar in their technology to the MNEs to benefit from spillovers. Overall, these results are extremely robust to specification changes, and indicate that there is not just one set of factors to explain FDI.

[1] The data mentioned above come from the World Investment Report, (2000).
[2] The core of the analysis of internalization was developed by Dunning (1977) and formalized by Horstmann and Markusen (1987).
[3] This analysis is formally developed in Ethier and Markusen (1996).
[4] Caves (1974) tested the spillover benefits of FDI in the manufacturing sectors of Canada and Australia. Blomstrom and Persson (1983) analyzed spillover effects for 215 four digit Mexican industries for 1970. Blomstrom and Wollf (1989) examined the difference between productivity growth in local and foreign firms for the Mexican manufacturing industries for the period 1965 to 1984.
[5] Inflow of foreign investment can react to GDP growth and other macroeconomic indicators such as stock market development.
[6] The calculation has been done separately and not reported in the table.
[7] R&D expenditures have increased from 3.46 billion in 1982 to 19.75 billion during 2000.
[8] For example, Caves (1996).
[9] Appendix 1 provides the list of variables and their sources.
[10] U.S. direct investment abroad is defined by the BEA as the ownership or control, directly or indirectly, by an U.S. resident of percent or more of voting securities of an incorporated foreign business enterprise or the equivalent interest in an unincorporated foreign business enterprise.
[11] This is the value of direct investors' equity and net outstanding loans to their affiliates. The position may be conceived as the direct investors' contributions to the total assets of the affiliates or as the financing provided in the form of equity or debt.
[12] Barrell and Pain (1996) found unit labor costs in the U.S. to be positively related to the level of outward investment, while Narula and Wakelin (2001) generally found a negative relation between unit labor costs and outward FDI. Recently, Hanson et al. (2001) has provided empirical evidence of the vertical FDI motive.
[13] Almeida (1996) finds Korean and European subsidiaries to make more use of sector specific knowledge in semiconductors from U.S. firms to upgrade their technological capability in areas in which they are relatively weak. Dalton and Serapio (1999) finds that foreign firms are trying to gain direct access to American technology and expertise, especially in biotechnology and electronics and are increasingly investing in R&D sites in the U.S. to access technologies that are complementary to them.
[14] See for example Keller (2001), The Geography and Channels of Diffusion at the World's Technology Frontier, NBER working paper No. 8150.
[15] BEA collects the aggregate of royalties and licensing fees and does not break each component into technology classes or the technology licensing arrangements between US firms and foreign parties.
[16] See for example, Hanson et al. (2001) and Narula and Wakelin (2001).
[17] In other words, the weights are proportional to the squared inverse of the variance of the residuals.
[18] The likelihood ratio test is based on the following statistic: $\lambda = -2 (\ln L_c - \ln L)$, where L_c denotes the log likelihood function with fixed effect estimation and L denotes the log likelihood function with cross-section weights imposed on the regressors. $\lambda = -2(124.24-192.16) = 135.84$. Under the null hypothesis, λ is distributed is distributed as χ^2_{13}. For 13 degrees of freedom, the critical value from the chi-squared table is 27.69, which leads to the rejection of the fixed effect model.
[19] Brainard (1997) for example finds that market size is more important than relative unit costs. The findings are consistent with the presence of horizontal multinationals.
[20] A recent study by Grunfeld (2000) with a sample of Norwegian firms during the period 1990 to 1996 finds that spillover motive increases the incentive to undertake more FDI. He finds that the presence of foreign ownership is more volatile in highly R&D intensive firms, since large R&D investments often result in large losses and gains, which may attract or repel foreign owners.
[21] It can be argued that R&D intensity of affiliates and patents granted to foreigners outweigh the tariff jumping motive as a rationale for outward FDI in these cases. In other words, the U.S. MNE is more motivated by technological intensity of the host country relative to tariff jumping motives.
[22] USPTO denotes the U.S. patent office.

APPENDIX 1

LIST OF VARIABLES AND SOURCES

The Data Set

The data set for this study is created from the Survey of Current Business of the Bureau of Economic Analysis (various editions), OECD (STAN, Main Science and Technology Indicators, ANBERD and Tariff and Trade database), World Bank Development Indicators and Groningen Growth and Development Center's economy wide database.

Variable Measurement and Sources

FDI: U.S. direct investment abroad on an historical cost basis
Source: Survey of Current Business, various editions.

GDP: Gross domestic product in 1990 millions of U.S. dollars
Source: Groningen Growth and Development Center's Economy wide database.

Population: Population figures in millions
Source: World Development Indicators, World Bank.

Unit Labor Cost Index: Unit labor costs in U.S. dollars, calculated by dividing total labor costs (in local currency by the relevant exchange rate) by value added in 1990 prices.
Source: STAN database, OECD.

Tariff: The bounded average tariff rates
Source: Tariff and Trade database, OECD.

R&D Expenditure: Total business R&D expenditures converted to millions of U.S. dollars using PPP rates
Source: ANBERD database, OECD.

R&D expenditures of affiliates: R&D expenditures of affiliates in millions of U.S. dollars
Source: http://www.bea.doc.gov/bea/ai/iidguide.htm#link12b

Patents: Number of Patents granted to inventors of the host country and the U.S. by the U.S. Patent office for various years
Source: Main Science and Technology Indicators, OECD.

Relative Patents: Obtained as the ratio of patents granted to foreigners to the patents granted to U.S. inventors; natural logarithm calculated

Exports: Exports in millions of U.S. dollars from the parent to the majority owned foreign affiliates for various years
Source: http://www.bea.doc.gov/bea/ai/iidguide.htm#link12b

Employment of Affiliates: Total employment in millions for majority owned foreign affiliates
Source: Survey of Current Business, various editions.

Total Employment: Total employment in the host country in millions
Source: STAN database, OECD.

Royalties and Licensing Fees: Total royalties and licensing fees in millions of U.S. dollars.
Source: http://www.bea.doc.gov/bea/di/1001serv/intlserv.htm

APPENDIX 2

BILATERAL TRADE INTENSITY MATRIX (1995)

The trade intensity matrix is obtained from the trade linkages and the trade matrices in the OECD interlink model by Fouler et al (2001). Since bilateral trade flow data are published with a much longer delay than data on imports and exports, the trade flow matrix are available for 1995 for all the member countries of the OECD in millions of U.S. dollars for the total of goods and services matrix. For a detailed discussion of the methodology and the problems in the construction, the reader is advised to consult this paper. The weights γ_{ji} are then constructed by dividing the corresponding exports from country j to another country i to the sum of exports from country j to all the other 13 countries in the sample. As evident from the table below the row sum always equals unity. The elements of the matrix are given below. The notations for the country are as follows: USA-United States, JPN- Japan, DEU-Germany, FRA-France, ITA-Italy, GBR-UK, CAN-Canada, AUS-Australia, BEL-Belgium, IRE-Ireland, NLD-Netherlands, ESP-Spain, SWE-Sweden, CHE-Switzerland.

Table 11: Bilateral Trade Intensity Matrix
(Sum of Total Goods and Services: 1995)

	USA	JPN	DEU	FRA	ITA	GBR	CAN	AUS	BEL	IRE	NLD	ESP	SWE	CHE
USA	0	0.227	0.081	0.051	0.031	0.11	0.31	0.034	0.034	0.012	0.052	0.02	0.01	0.022
JPN	0.575	0	0.097	0.034	0.021	0.084	0.027	0.039	0.023	0.009	0.048	0.01	0.008	0.016
DEU	0.13	0.041	0	0.174	0.111	0.13	0.009	0.01	0.089	0.007	0.118	0.05	0.038	0.08
FRA	0.104	0.031	0.236	0	0.125	0.122	0.009	0.006	0.105	0.006	0.06	0.1	0.017	0.076
ITA	0.15	0.033	0.27	0.187	0	0.089	0.013	0.009	0.04	0.005	0.04	0.07	0.013	0.066
GBR	0.21	0.044	0.167	0.123	0.064	0	0.019	0.024	0.066	0.07	0.09	0.05	0.033	0.029
CAN	0.86	0.05	0.016	0.011	0.007	0.023	0	0.005	0.007	0.001	0.007	0.002	0.002	0.004
AUS	0.175	0.517	0.044	0.024	0.038	0.109	0.02	0	0.014	0.003	0.02	0.008	0.006	0.018
BEL	0.07	0.017	0.264	0.22	0.066	0.103	0.003	0.004	0	0.004	0.167	0.036	0.018	0.019
IRE	0.104	0.034	0.173	0.113	0.045	0.301	0.01	0.007	0.05	0	0.08	0.03	0.022	0.021
NLD	0.07	0.018	0.337	0.131	0.064	0.116	0.006	0.004	0.154	0.007	0	0.034	0.025	0.027
ESP	0.074	0.017	0.222	0.295	0.13	0.112	0.009	0.004	0.04	0.005	0.048	0	0.012	0.024
SWE	0.14	0.048	0.217	0.087	0.061	0.16	0.017	0.021	0.07	0.01	0.09	0.034	0	0.035
CHE	0.115	0.061	0.346	0.140	0.103	0.079	0.012	0.013	0.022	0.004	0.05	0.03	0.019	0

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Table 1: Outward Distribution of U.S. FDI by Regions (Millions of U.S. dollars)

	Years			
Regions	1985	1990	1995	2000
Canada	47,934 (20.11)	69,508 (16.14)	83,498 (11.95)	128,814 (9.96)
Europe	108,664 (45.59)	214,739 (49.88)	344,596 (49.30)	679,457 (52.53)
Latin America & Western Hemisphere	30,417 (12.76)	71,413 (16.59)	131,377 (18.79)	251,863 (19.47)
Africa	6,130 (2.56)	3,650 (0.85)	6,017 (0.86)	14,417 (1.11)
Middle East	4,554 (1.91)	3,959 (0.85)	7,198 (1.03)	11,087 (0.86)
Asia & Pacific	35,294 (14.81)	64,718 (15.03)	122,711 (17.55)	205, 317 (15.87)
International	5,378 (2.26)	2,535 (0.59)	3,618 (0.52)	2,476 (0.19)
Developed Countries	175,335 (73.55)	324,138 (75.29)	487,920 (69.80)	894,963 (69.20)
Developing Countries	63,036 (26.45)	106,384 (24.71)	211,095 (30.20)	398,468 (30.80)
Total	238,371	430,522	699,015	129,3431

Note: Figures in parentheses denotes the percentage share of U.S. outward FDI.
Developed countries included are Canada, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK, Australia, Japan, and New Zealand.

Table 2: Overseas R&D Expenditures by U.S. Affiliates (Millions of U.S. Dollars)

	1982	1989	1995	2000
Total R&D exp	3462.33	7048	12,582	19758
Canada	505 (14.59)	914 (12.97)	1,068 (8.48)	1874 (9.48)
Belgium	223 (6.44)	317 (4.50)	292 (2.32)	410 (2.08)
France	263 (7.60)	545 (7.73)	1,271 (10.10)	1445 (7.31)
Germany	893 (25.79)	1496 (21.22)	3,068 (24.38)	3105 (15.72)
Ireland	31 (0.90)	134 (1.90)	171 (1.36)	518 (2.62)
Italy	150 (4.33)	294 (4.17)	346 (2.75)	575 (2.91)
Netherlands	65 (1.88)	360 (5.11)	495 (3.93)	369 (1.87)
Spain	36 (1.04)	115 (1.63)	288 (2.29)	196 (0.99)
Sweden	28 (0.81)	33 (0.47)	691 (5.49)	1335 (6.76)
Switzerland	60 (1.73)	67 (0.95)	242 (1.92)	220 (1.11)
UK	824 (23.80)	1673 (23.73)	1,935 (15.38)	4154* (21.02)
Japan	104 (3.00)	488 (6.92)	1,286 (10.22)	1433 (7.25)
Australia	114 (3.29)	191 (2.71)	287 (2.28)	330 (1.67)
Singapore	12.33 (0.36)	25 (0.35)	63 (0.50)	548 (2.77)
Brazil	97 (2.80)	90 (1.28)	249 (1.98)	250 (1.26)
Mexico	30 (0.87)	37 (0.52)	58 (0.46)	305 (1.54)
South Africa	23 (0.66)	9 (0.13)	17 (0.14)	22 (0.11)

Sources: R&D expenditures of R&D affiliates is from the Bureau of Economic Analysis. Numbers in parentheses are percentages of R&D expenditures by majority owned, non-bank affiliates and do not round up to 100 since other countries are present. * denotes estimated R&D expenditures.

Table 3: Ratio of U.S. R&D Abroad to Domestic R&D for Selected Industries: 1998

Industries	R&D Abroad ($ Millions)	Domestic R&D ($ Millions)	Ratio of R&D Abroad to Domestic R&D (in percent)
All Manufacturing	16,008	145,016	11.04
Chemicals	2,635	18,733	14.06
Machinery	741	5,831	12.71
Computers	1,585	31,873	4.97
Electronic equipment	109	2,139	5.10
Transportation equipment	4,273	20,677	20.66
Professional & R&D service	384	11,440	3.36
Information	1,322	13,025	10.15

Source: Science and Engineering Indicators, National Science Foundation (2002).

Table 4: U.S. R&D Facilities by Countries: 1997

Country	No. of R&D Facilities
All Countries	186
Japan	43
UK	27
Belgium	8
Canada	26
Denmark	2
France	16
Germany	15
Ireland	2
Italy	3
Luxembourg	2
Netherlands	2
Spain	1
Sweden	1
Switzerland	2
China	11
India	3
Brazil	2
Singapore	13
Mexico	3
Taiwan	2

Source: Globalizing Industrial Research and Development Report, Office of Technology Administration (1999).

Table 5: U.S. Patents by Inventor Country for Selected Years Granted by USPTO[22]

Inventor Country	1985	1990	1995	1999
All OECD	75,699	103,491	135,048	159,428
USA	38,730 (51.16)	55,694 (53.81)	75,560 (55.95)	83,907 (52.63)
Belgium	309 (0.41)	368 (0.35)	627 (0.46)	648 (0.41)
Canada	1,338 (1.77)	1,996 (1.93)	2,723 (2.01)	3,952 (2.48)
France	2,649 (3.50)	3,209 (3.10)	3,649 (2.70)	3,820 (2.40)
Germany	7,303 (9.65)	7,346 (7.10)	9,159 (6.78)	9,337 (5.86)
Ireland	44 (0.06)	62 (0.06)	86 (0.06)	94 (0.06)
Italy	1,157 (1.53)	1,311 (1.27)	1,457 (1.08)	1,492 (0.94)
Netherlands	825 (1.09)	927 (0.90)	1,197 (0.89)	1,247 (0.78)
Spain	104 (0.14)	149 (0.14)	232 (0.17)	222 (0.14)
Sweden	819 (1.08)	798 (0.77)	1,268 (0.94)	1,401 (0.88)
Switzerland	1,239 (1.64)	1,211 (1.17)	1,277 (0.95)	1,279 (0.80)
UK	2,704 (3.57)	2,758 (2.66)	3,258 (2.41)	3,572 (2.24)
Japan	16,701 (22.06)	25,020 (24.18)	28,539 (21.13)	31,104 (19.51)
Australia	472 (0.62)	544 (0.52)	654 (0.48)	707 (0.44)

Source: Main Science and Technology Indicators, OECD (2002).
Numbers in parentheses are percentage of patents granted by the USPTO to inventor of other countries and does not round up to 100 since other OECD countries are present.

Table 6: Weighted Least Squares Estimates of Outward FDI (Period: 1982-2000)

Variable Name	Equations				
	(1)	(2)	(3)	(4)	(5)
Intercept	2.74**	1.15	0.89	0.89	3.56*
	(0.74)	(1.02)	(1.03)	(1.02)	(1.09)
a (GDP)	0.07*	0.07*	0.077**	0.08**	0.04
	(0.014)	(0.016)	(0.032)	(0.032)	(0.03)
GDPCAP	0.02	0.18	0.21	0.21	-0.002
	(0.13)	(0.14)	(0.13)	(0.13)	(0.15)
ULC	0.00	-0.00	-0.00	-0.00	-0.00
	(0.0005)	(0.0004)	(0.0004)	(0.0004)	(-0.63)
R&D to GDP of host	0.17**				
	(0.06)				
R&D to GDP of the US	0.179				
	(0.10)				
R&D intensity of affiliates		0.048			
		(0.043)			
R&D sum			0.00		
			(0.0005)		
R&D difference				-0.00	
				(0.0005)	
RELPAT					0.04*
					(0.01)
τ (tariff)	3.51*	2.76*	2.83**	2.83**	3.35*
	(0.77)	(0.73)	(1.00)	(0.99)	(0.76)
E_{-1} (lagged exports)	0.59*	0.63*	0.62*	0.63*	0.61*
	(0.03)	(0.02)	(0.02)	(0.02)	(0.035)
Time dummy	0.06*	0.05*	0.05*	0.05*	0.06*
	(0.006)	(0.007)	(0.006)	(0.006)	(0.007)
Adjusted R^2	0.80	0.81	0.81	0.806	0.802
RSS	47.64	49.29	49.83	49.84	43.77
Wald Statistic on patent restrictions					7.98 (0.005)

Notes: Standard errors in parentheses for parameters, p-values in parentheses for statistics. * denotes at 1% level of significance. ** denotes at 5% level of significance. Measure of market size is GDP in millions of 1990 U.S. dollars.

Table 7: Weighted Least Squares Estimates of Outward FDI (Population as Measure of Market Size)

Variable Name	Equations				
	(1)	(2)	(3)	(4)	(5)
Intercept	2.74**	1.15	0.89	0.89	3.56*
	(0.97)	(1.02)	(1.03)	(1.03)	(1.09)
a (POP)	0.07*	0.07*	0.077**	0.08**	0.04
	(0.014)	(0.016)	(0.032)	(0.032)	(0.03)
GDPCAP	0.05	0.26	0.29**	0.29**	0.03
	(0.12)	(0.134)	(0.12)	(0.12)	(0.13)
ULC	0.00	-0.00	-0.00	-0.00	-0.00
	(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
R&D to GDP of host	0.16**				
	(0.06)				
R&D to GDP of the US	0.179 (0.10)				
R&D intensity of affiliates		0.048			
		(0.043)			
R&D sum			0.00		
			(0.0005)		
R&D difference				-0.00	
				(0.0005)	
RELPAT					0.04*
					(0.01)
τ (tariff)	3.50*	2.76*	2.83**	2.83**	3.35*
	(0.77)	(0.72)	(1.00)	(0.99)	(0.76)
E_{-1} (lagged exports)	0.59*	0.63*	0.62*	0.63*	0.61*
	(0.04)	(0.02)	(0.02)	(0.02)	(0.035)
Time dummy	0.06*	0.05*	0.05*	0.05*	0.06*
	(0.007)	(0.007)	(0.006)	(0.006)	(0.007)
Adjusted R^2	0.802	0.806	0.81	0.806	0.802
RSS	57.76	49.29	49.83	49.83	43.77
Wald Statistic on patent restrictions					7.98 (0.005)

Notes: Standard errors in parentheses for parameters, p-values in parentheses for statistics.
* denotes at 1% level of significance. ** denotes at 5% level of significance. Measure of market size is proxied by population in millions.

Table 8: Spillover Versus Intangible Asset Acquisition Motives in Outward FDI (Period: 1982-2000)

Variable Name		Equations
	(1)	(2)
Intercept	4.41	5.30**
	(2.54)	(1.67)
A (GDP)	-0.07	-0.08
	(0.04)	(0.03)
GDPCAP	0.52*	0.14
	(0.07)	(0.22)
ULC	-0.00	-0.001
	(0.0006)	(0.0005)
IS (Employment spillovers)	0.09*	
	(0.02)	
R_{US}^p (Trade spillovers)		0.15
		(0.09)
Z (Royalties and Licensing fees)	0.11*	0.27*
	(0.03)	(0.048)
T (tariff)	2.28**	3.28*
	(1.06)	(1.11)
E_{-1} (lagged exports)	0.48*	0.54*
	(0.02)	(0.02)
Time dummy	0.02*	0.05*
	(0.004)	(0.01)
Adjusted R^2	0.801	0.812
RSS	41.45	42.81
Wald Statistic	81.64 (0.00)	12.01 (0.0006)

Notes: Standard errors in parentheses for parameters, p-values in parentheses for statistics. * denotes at 1% level of significance. ** denotes at 5% level of significance.
Measure of market size is proxied by GDP. The Wald Statistic tests whether spillover effect dominates over asset acquisition effect.

Table 9: Testing for Non-linear Relation Between Spillovers and FDI (Period: 1982-2000)

Variable Name	Equations	
	(1)	(2)
Intercept	3.97**	0.96
	(1.10)	(1.26)
a (GDP)	0.01	0.056**
	(0.04)	(0.017)
GDPCAP	0.09	0.17
	(0.14)	(0.170)
ULC	-0.00	-0.00
	(0.0004)	(0.0004)
IS (Employment spillovers)	0.30	
	(0.05)*	
IS^2	-0.10	
	(0.04)	
R_{US}^p (Trade spillovers)		-0.61
		(0.16)**
R_{US}^{p2}		0.34
		(0.09)**
τ (tariff)	2.66**	2.62**
	(1.12)	(0.98)
E_{-1} (lagged exports)	0.52*	0.63*
	(0.02)	(0.02)
Time dummy	0.05*	0.04*
	(0.007)	(0.01)
Adjusted R^2	0.798	0.807
RSS	42.96	45.44

Notes: Standard errors in parentheses for parameters, p-values in parentheses for statistics. * denotes at 1% level of significance. ** denotes at 5% level of significance.

Table 10: Weighted Least Squares Estimates of Outward FDI: Dependent variable FDI per worker (Period: 1982-2000)

Variable Name		Equations			
	(1)	(2)	(3)	(4)	(5)
Intercept	7.58 *	6.47*	4.69*	4.71*	5.97*
	(1.00)	(0.94)	(1.00)	(1.00)	(1.28)
GDPCAP	0.57*	0.70*	0.83*	0.83*	0.74*
	(0.13)	(0.137)	(0.12)	(0.12)	(0.15)
ULC	0.00	-0.00	-0.00	-0.00	-0.00
	(0.0005)	(0.0004)	(0.0005)	(0.0005)	(-0.005)
R&D to GDP of host	0.23*				
	(0.07)				
R&D to GDP of the US	0.19				
	(0.12)				
R&D intensity of affiliates		0.15*			
		(0.04)			
R&D sum			0.001		
			(0.0005)		
R&D difference				-0.00	
				(0.0005)	
RELPAT					0.07**
					(0.03)
τ (tariff)	1.85**	1.47	2.66**	2.64**	1.31
	(0.92)	(0.91)	(1.16)	(1.15)	(1.04)
E_{-1} (lagged exports)	0.55*	0.58*	0.57*	0.57*	0.60*
	(0.03)	(0.02)	(0.02)	(0.02)	(0.04)
Time dummy	0.08*	0.071*	0.06*	0.06*	0.06*
	(0.007)	(0.007)	(0.006)	(0.006)	(0.009)
Adjusted R^2	0.805	0.818	0.818	0.81	0.815
RSS	63.32	59.33	59.38	59.41	55.30
Wald Statistic on R&D sum and difference				2.63 (0.105)	

Notes: Standard errors in parentheses for parameters, p-values in parentheses for statistics. * denotes at 1% level of significance. ** denotes at 5% level of significance. Measure of market size is GDP in 1990 U.S. dollars.