

# **On the Determinants of Euro Area FDI to the United States: The OLI-Tobin's Q Framework**

by

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**Abstract:** This paper aims to explain the long-run determinants of euro area FDI to the United States during the period 1980-2001. The theoretical model developed in this paper incorporates the traditional FDI model based on the OLI-framework into the Tobin's Q-model of investment. The model is estimated using the fixed effects panel estimator, with the euro area proxied by a panel involving most of the euro area countries. In accordance to the theoretical model, the investment climate in the euro area, as reflected in Tobin's Q – including a measure adjusted for economic developments common to both the United States and the euro area - is found to influence euro area FDI to the United States. Moreover, the inclusion of the Tobin's Q seems to enhance the traditional OLI framework specification by adding further explanatory power to the FDI equation. Overall, the empirical findings suggest that euro area patents (ownership advantage), various variables related to productivity in the United States (location advantage), the volume of bilateral telephone traffic to the United States relative to euro area GDP (location advantage), Tobin's Q and the real exchange rate (capital gains) are statistically significant determinants of euro area FDI to the United States.

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We would like to thank participants to an ECB internal seminar, where an earlier version of this paper was presented, for their very useful comments and Lorenzo Cappiello and Stelios Makrakakis for valuable suggestions. However, the views expressed in this paper are those of the authors and do not necessarily represent those of the ECB or the Eurosystem.

## 1. Introduction

Foreign direct investment (FDI) skyrocketed in the 1990s from USD 200 billion in 1990 to USD 1500 billion in 2000 to decline to USD 735 billion in 2001. Most FDI occurred between developed countries. For example, in 2001 the European Union, Japan and the United States alone accounted for 61% of world inflows and 77% of world outflows (UNCTAD, 2002). Traditionally, the United States has been one of the largest recipients of FDI accounting for 17% of world inflows in 2001 (UNCTAD, 2002). Also, euro area companies invested extensively in the United States. The share of euro area FDI to the United States relative to total FDI inflows in the United States, while characterised by a U-shape in the 1980s, increased from 34% in 1980 and in 1990 to 64% in 2001. The stock of euro area FDI in the United States in real terms in 2001 was around fourteen times as large as it was in 1980. However, most of this growth occurred in the second half of the 1990s, as the size of real euro area FDI outflows to the United States reached their peak in 2000, amounting to around ten times the magnitude of outflows in 1995. In 2001 alone, the FDI outflows from the euro area to the United States amounted to 1.6% of euro area GDP and 1.3% of US GDP. In view of these developments, investigating the determinants of euro area FDI in the United States constitutes an important and interesting undertaking.<sup>1</sup>

The theoretical and empirical literature on FDI is generally based on the so-called OLI-framework proposed by Dunning (1977).<sup>2</sup> Dunning identifies three conditions that must be satisfied for there to be a strong incentive for a firm to engage in FDI. First, a firm must have an *Ownership advantage* for a product or production process to which other firms do not have access (i.e., patent, blueprint, or trade secret).<sup>3</sup> Second, the foreign country must offer a

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<sup>1</sup> Examples of other papers that empirically analyse the long-run determinants of aggregate FDI are Cushman (1985, 1988), Barrell and Pain (1996, 1997) and Cheng and Kwan (2000).

<sup>2</sup> OLI stands for *Ownership, Location and Internalisation* advantage.

<sup>3</sup> For example, Barrell and Pain (1997) concentrate on the role of firm-specific assets in the form of technology.

*Location advantage* such that goods can be produced or supplied more cheaply. More recently, stronger emphasis has been given to vertical location advantages which induce quality-seeking FDI or technological sourcing (see Kogut and Chang, 1991; Neven and Siotis, 1996; Fosfuri and Motta, 1999). Third, the multinational firm must have an *Internalisation advantage*, i.e. a strategic reason to exploit its ownership advantage internally rather than licensing or selling it to a foreign firm.

In the trade literature, the OLI-framework has been formalised in the so-called knowledge-capital models of multinational enterprises.<sup>4</sup> Those models look at the FDI implications for market structure, welfare, the equilibrium number of national and multinational firms in a static framework, where FDI is generally exogenously specified as a fixed cost to set-up a plant abroad (Markusen and Venables, 1998; De Santis and Stähler, 2003). Similarly, the empirical studies based on these models generally develop predictions about affiliate production (Carr et al, 2001, Blonigen et al., 2002).

The present paper derives FDI from an intertemporal maximisation problem faced by the multinational firm. In other words, we adopt an investment-based approach à la Tobin (Tobin, 1969) with convex adjustment costs.<sup>5</sup> We argue that Tobin's Q is particularly appropriate for modelling FDI because adjustment costs in international investment are likely to be much higher than for domestic investment. Jovanovic and Rousseau (2002), for example, show that the Q-theory of investment can be used to explain investment via mergers and acquisitions (M&A). They find that M&A investment, which is a sub-component of FDI, responds to stock market developments by more than direct investment.

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<sup>4</sup> For an overview see Markusen and Maskus (2001) and Markusen, 2002.

<sup>5</sup> Generally, studies have found only weak evidence of a positive relationship between stock market valuation and investment. More recently, however, Erickson and Whited (2000) and Bond and Cummins (2001) have re-examined this relationship, and claim that measurement error has reduced the statistical significance of Q in empirical work.

The theoretical model is evaluated empirically by using a panel of eight (or sometimes nine) euro area countries for the period 1980 to 2001. In line with the theoretical model, a dynamic partial adjustment model is specified and estimated using the least squares dummy variable (LSDV) estimator.

The empirical results provide support to the theoretical predictions. The investment climate in the euro area as reflected in Tobin's Q – including a measure adjusted for economic developments common to both the United States and the euro area – is found to influence euro area FDI to the United States. Moreover, the inclusion of Tobin's Q seems to enhance the traditional OLI framework specification by adding further explanatory power to the FDI equation. Overall, the empirical findings suggest that euro area patents (ownership advantage), various variables related to productivity in the United States (location advantage), the volume of bilateral telephone traffic to the United States relative to euro area GDP (location advantage), Tobin's Q and the real exchange rate (capital gains) are statistically significant determinants of euro area FDI to the United States.

The remainder of the paper is structured as follows. Data and trends in FDI are briefly discussed in Section 2. Section 3 presents the theoretical model of FDI based on the OLI framework and Tobin's Q. Section 4 presents the data set. Section 5 discusses the empirical results. Section 6 concludes.

## **2. Foreign direct investment: Definitions and trends**

FDI is defined as the acquisition of foreign assets (based on residence) with the intention to exert control. This definition has at least two important features. First, FDI reflects entering

into a long-term relationship with the host country. Second, FDI does not merely represent a transfer of resources across national borders, but also a transfer of corporate control.<sup>6</sup>

This study uses international investment position data in order to construct a series of the stock of FDI for the twelve euro area countries in the United States for the period 1980-2001. The data are obtained from the Bureau of Economic Analysis (BEA), which defines the “intention to exert control” as ownership of more than 10%. These data measure the value of the parent firms’ financial stakes in their foreign affiliates. As such, direct investment position data measure FDI as an input of production (Lipse, 2001).<sup>7</sup>

Figure 1 shows the aggregate euro area stock of FDI in the United States, as well as the annual outflows, calculated at 1995 constant prices (both expressed as indices with 2000 as the base year). It is clear that the real stock of euro area FDI held in the United States has increased exponentially over the past two decades. The real stock of FDI in 2001 was fourteen times as large as it was in 1980. On average, the real stock of FDI increased by 14% each year over the period 1980-2001, but the growth in the stock of FDI was particularly strong in the second half of the 1990s. For example, the euro area’s real stock of FDI in the United States grew by almost 30% in 1999, while the size of real euro area FDI outflows to the United States reached their peak in 2000 amounting to around ten times the magnitude of outflows in 1995.

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<sup>6</sup> Direct investments consist of equity capital, intercompany debt and reinvested earnings. Equity capital comprises payments made by the investing company with the objective to change its ownership position. Intercompany debt includes all transactions between the investor company involving borrowing and lending of funds. Reinvested earnings are the shares of the after-tax earnings of the affiliates corresponding to the investing company. In 2001 the shares of equity capital, inter-company debt and reinvested earnings in total euro area FDI in the United States were 65%, 43% and -9% respectively (Source: BEA and own calculations).

<sup>7</sup> It is important to stress that investment position data are based on the immediate sources and destinations of investment, whereas the ultimate source and final destination might be located in different industries or countries (Lipse, 2001). This could lead to the overestimation of financial “hubs” as sources or destinations of investment (i.e. Luxembourg and the Netherlands).

*[Insert Figure 1, here]*

Figure 2 shows the distribution of the euro area's stock of FDI in the United States, indicating that the bulk of euro area FDI to the United States is accounted for by a few countries. Back in 1980, the Netherlands was responsible for 52% of the stock of euro area FDI in the United States followed by Germany and France which held 20% and 14% of the stock respectively. In the 1990s Germany, France and Luxembourg gained substantially in importance as FDI investors in the United States. By 2001, Germany was the biggest investor holding 31% of the euro area stock of FDI in the United States, while the share of the Netherlands fell to 29%, France had 22% and Luxembourg 13%. The seemingly disproportionate share of the Netherlands and Luxembourg in euro area FDI may be related to methodological issues regarding the classification of the data.<sup>8</sup> Both countries may act as hubs for FDI resulting from a highly developed and sophisticated financial sector combined with favourable fiscal policies for firms. In addition, we do not have sufficient data for all of the explanatory variables for Luxembourg, therefore, this country was excluded from the empirical analysis. With regard to the Netherlands, it might be appropriate during the econometric analysis to check the robustness of the results by at first including, and then excluding, this country from the sample.

*[Insert Figure 2, here]*

Figure 3 plots the movements of stock markets in France, Germany and the Netherlands, the three major euro area countries undertaking FDI activities, against euro area

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<sup>8</sup> According to data from the Thomson Merger and Acquisition (M&A) database for 2001 based on ultimate source and target country, Germany and France both account for 31% of the stock of euro area FDI in the US (based on cumulated M&A), the Netherlands for 25% and Luxembourg for only 2%. Thus, it is clear that Luxembourg ought to be excluded from the sample as the data classification method changes the picture dramatically, while for the Netherlands the decision whether or not to exclude it is far from obvious and should be considered as an empirical question.

real FDI outflows to the United States. It can be seen that euro area real FDI outflows and stock market indices tend to show a significant degree of co-movement over the sample period. Accordingly, Figure 3 suggests that the value of the corporate sector could be a factor positively affecting euro area outward FDI to the United States.

*[Insert Figure 3, here]*

A sectoral analysis of euro area FDI to the United States – using the M&A database of Thomson Financial – provides some useful insights. For example, Figure 4 (based on the average for the period 1985-2001) shows that services – excluding the financial sector – accounted for 31.1% of total M&As, financial services received 14.9%, while manufacturing amounted to 35.7%. One striking feature is that the proportion of “high-tech” US companies acquired by euro area firms has been increasing over time. In particular, the boom in euro area FDI to the United States in the mid-to-late 1990s was concentrated in high-tech industries. In 2001, for example, the high-tech industries (i.e. a composite of biotechnology, computer equipment, electronics and communication technology sectors, etc.) accounted for 47% of total euro area M&A in the United States compared to an average of 32% over the years 1998-2001 and an average of 21% over the period 1985-1997.

These stylised facts suggest that euro area corporate sector valuation, as well as the internalisation of US knowledge capital, may be important factors affecting euro area FDI activities to the United States.

*[Insert Figure 4, here]*

### **3. A Model of FDI with convex adjustment costs**

Consider an industry with a large number of multinational firms. Each firm is characterised by the following production functions:  $F\{k_t, P_t\}$  in the home country and  $G\{k_t, K_t^j, P_t\}$  in the host country, where  $k_t$  denotes the firm’s capital stock;  $P_t$  the multinational firm-specific asset

(ownership advantage) and  $K_t^j$  the knowledge-capital in the host country (location advantage). The multinational firm is able to produce a specific product and is willing to undertake FDI, although it is costly, to enjoy the foreign technological advantages, which can be internalised only by having a presence abroad (Fosfuri and Motta, 1999). In general,  $K_t^j$  can be interpreted as the country-specific variables, which increase firms' output, such as technology, flexibility of the labour markets, other institutions, etc.

Assume that markets are segmented so that each firm maximises the present value of its profit function with respect to its inputs and with respect to both domestic and foreign investment.<sup>9</sup> In addition, assume that each firm faces costs of adjusting its capital stock and independently chooses the profit-maximising investment for each country. Then, the firm's profit flow abroad is given by

$$(1) \quad V_t^j = \int_{s=t+1}^{\infty} e^{-r(s-t)} \left[ \frac{p_s^G}{x_s} \left( G\{k_s, P_s, K_s^j\} - \frac{\delta}{2} FDI_s^2 \right) - FDI_s \right] ds,$$

where  $x_t$  denotes the exchange rate (host country currency relative to the home country currency),  $p_t^G$  the foreign goods price,  $FDI_t$  firm's FDI,  $\delta$  firm's cost parameter of adjusting its capital stock and  $r$  the constant real interest rate. On the one hand, the more rapidly the firm adjusts its stock of capital, the lower its profits are. On the other hand, the higher the spillovers from the host country and the expected appreciation of the foreign currency, the higher its profits would be.

The current-value Hamiltonian for the firm's maximisation problem is

$$(2) \quad H\{k_t, FDI_t\} = \left[ \frac{p_s^G}{x_s} \left( G\{k_t, P_t, K_t^j\} - \frac{\delta}{2} FDI_t^2 \right) - FDI_t \right] + q_t [FDI_t - \dot{k}_t],$$

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<sup>9</sup> In order to allow for positive levels of investment at home and abroad we assume that multinational firms are not financially constrained. Stevens and Lipsey (1991) analyse the interdependence between domestic and foreign investment when firms are financially constrained. However, they only provide weak evidence that outward FDI competes with domestic investment.

where  $q_t$  denotes the shadow price of the state variable  $k_t$  and  $FDI_t$  is the control variable.

The firm's maximisation problem implies the following conditions:

$$(3) \quad 1 + \frac{p_t^G}{x_t} \delta FDI_t = q_t,$$

$$(4) \quad \frac{p_t^G}{x_t} G_k \{k_t, p_t, K_t^j\} = r q_t - \dot{q}_t,$$

$$(5) \quad \lim_{t \rightarrow \infty} e^{-rt} q_t k_t = 0.$$

The first condition implies that the firm invests up to the point where the cost of acquiring capital equals the value of the capital. FDI is positive only when the shadow price  $q_t$  of installed capital exceeds unity, the price of new, uninstalled capital. The second condition implies that the marginal revenue product of capital in the home currency equals the opportunity cost of a unit of capital. Owning a unit of capital for a period requires forgoing  $r q_t$  of real interest and involves offsetting gains of  $\dot{q}_t$ . The transversality condition states that the value of the capital stock must approach zero.

Provided that permanent bubbles in the shadow price of capital are ruled out, so that

$\lim_{T \rightarrow \infty} e^{-r(T-t)} q_T = 0$ , the solution of the differential equation (4) yields the so-called marginal-Q:

$$(6) \quad q_t = \int_{s=t+1}^{\infty} e^{-r(s-t)} \frac{p_s^G}{x_s} G_k \{k_s, p_s, K_s^j\} ds.$$

The value of a unit of capital at a given time equals the discounted value of its future marginal revenue products. By using (6), (3) can be rewritten as follows:

$$(7) \quad FDI_t = \frac{1}{\delta} \frac{x_t}{p_t^G} \left( \int_{s=t+1}^{\infty} e^{-r(s-t)} \frac{p_s^G}{x_s} G_k \{k_s, p_s, K_s^j\} ds - 1 \right).$$

Following Hayashi (1982), as for aggregate domestic investment, euro area FDI decisions would depend positively on the market value of the euro area firms divided by their replacement cost of capital. Hence, the euro area Tobin's Q – which takes into account the

impact of euro area equity market developments on investment – should be a factor explaining euro area FDI activities.

As mentioned earlier, it seems that the technology boom in the United States – and the desire of euro area firms to acquire the new technologies of US companies – seems to have been a key factor behind FDI outflows to the United States, particularly in the second-half of the 1990s. This motivation for undertaking FDI would fall under the heading of vertical location advantages within the OLI-framework. In order to understand more fully the role of these vertical location advantages, namely the importance of US-specific technology variables as a pull factor of euro area FDI, assume that capital markets are imperfect and that  $F\{k_t, P_t\} = P_t k_t^{1-\alpha}$  and  $G\{k_t, K_t^j, P_t\} = P_t K_t^j k_t^{1-\alpha}$  with  $0 < \alpha < 1$ . Then, (7) can be re-written as

$$(8) \quad FDI_t = \frac{1}{\delta} \frac{z_t}{p_t^F} \left[ \int_{s=t+1}^{\infty} e^{-r(s-t)} \left( K_s^j p_s^F F_k\{k_s, P_s\} \frac{1}{z_s} \right) ds - 1 \right].$$

where  $p_t^F$  denotes the domestic goods price and  $z_t = x_t \frac{p_t^F}{p_t^G}$  the real exchange rate.

The reduced form (8) shows that FDI is a positive function (of the discounted value) of the knowledge capital of the host country (vertical location advantage) and of the marginal revenue product of capital in the home country excluding the spillovers coming from the host country (investment climate in the euro area).<sup>10</sup>

Therefore, two alternative specifications could be studied: first, the Tobin's Q represented by (7); second, the separation of Tobin's Q into the vertical location element and the part relating to the investment climate in the euro area, as represented by (8). Accordingly, by

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<sup>10</sup> In addition, equation (8) also shows that FDI is a positive function of the contemporaneous appreciation of the home country's real exchange rate and a negative function of its future appreciation. In particular, the subsequent appreciation of the US dollar, by increasing the value of the discounted stream of expected profits in the United States expressed in terms of the home currency, would encourage euro area FDI to the United States. Under the hypothesis that prices are relatively sticky and that the exchange rate is a random walk, then one can expect a negative relationship between FDI activities and the real exchange rate.

using proxies for what we call “unadjusted”,  $\int p_s^G G_k / x_s$ , and “adjusted”,  $\int p_s^F F_k$ , Tobin’s Q, two alternative specifications are tested. If stock market developments adequately capture vertical location advantages, we expect US technology variables to be insignificant when using the unadjusted Tobin’s Q and significant when using the adjusted measure. Since the Tobin’s Q model is based upon the assumption that the optimal stock of capital does not adjust instantaneously to shocks, a standard econometric framework to capture this feature is the partial adjustment model, which we estimate in Section 5.<sup>11</sup>

## 4. Data, variables and econometric specification

### 4.1 Proxying Tobin’s Q

The marginal Q,  $\int p_s^G G_k / x_s$ , in equation (7) reflects the discounted value of the marginal product of capital in the euro area, which determines the level of investment abroad – we call this the “unadjusted” Tobin’s  $Q_{it}$ . It is not observable. However, under the assumptions of perfect competition and constant return to scale, the marginal Q is equal to the stock market capitalisation divided by the replacement cost of capital (Hayashi, 1982).<sup>12</sup> Given the difficulty of compiling comparable capital stock data for each euro area country, marginal-Q is proxied by the domestic stock market index of each euro area country. In this regard, it is important to mention that the stock market capitalisation divided by the replacement cost of capital is strongly correlated with developments in stock market prices. For example, the

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<sup>11</sup> The partial adjustment model can be implemented either in a static or in a dynamic model specification. Barrel and Pain (1996) and Cheng and Kwan (2000) constitute examples of studies that adopt a dynamic specification. Goldsbrough (1979) and Cushman (1985) provide examples of studies that have adopted a partial adjustment model in a static empirical specification. As a result, they regress FDI flows on their long-run constituents and the lagged stock of FDI.

<sup>12</sup> In our model, the assumption that the production function is characterised by constant returns to scale can be obtained by assuming that labour is an additional input of production and that  $\alpha$  is the labour market share.

correlation coefficient between these two variables for both Germany and the United States is equal to 99% over the monthly period 1973-2003. Therefore, as also suggested by Barro for the United States (1990), the stock market price is a good proxy for the discounted stream of the future marginal product of capital. Expression (7) also suggests that the stock market indices should be measured in real terms.

The investment climate in the euro area  $\int p_t^F F_k$  in equation (8) reflects euro area marginal Q excluding the positive vertical location spillovers from the host country, and we call this the “adjusted” Tobin’s  $\tilde{Q}_{it}$  measure. By using  $\int p_t^F F_k$ , one could consider the present model as an extension of the OLI-framework by controlling for the investment climate in the euro area. This could, therefore, provide a test as to whether Tobin’s Q adds further explanatory power in addition to the variables included in the traditional OLI framework.

The problem is how to adjust the Tobin’s Q measure, as proxied by the real euro area stock market index, in order to subtract the vertical location advantages and, thereby, derive  $\tilde{Q}_{it}$ . Our methodology to derive  $\tilde{Q}_{it}$  is to regress the real euro area stock market indices on the real US stock market index and use the residuals as our measure of  $\tilde{Q}_{it}$ . We choose this methodology partly because it also has the added advantage that it corrects for any excessive correlation between stock markets across the two economic areas and also subtracts any vertical location spillovers from US firms to euro area multinational enterprises. Controlling for the excessive correlation of stock markets across the two economic areas, also removes the stock market bubble of the late 1990s and, consequently, helps in dealing with some theoretical considerations relating to equity bubbles.<sup>13</sup> Indeed, with hindsight, there seems

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<sup>13</sup> Forbes and Rigobon (1999) point out that the high comovement of national stock markets in the second half of the 1990s may have not reflected economic fundamentals, but the result of global integration. Therefore, the comovement may be considered as excessive.

now likely to have been an overvaluation in equity markets during the second half of the 1990s. To the extent that the euro area stock market was assumed to have been subject to a permanent bubble, the theoretical model relating to Tobin's Q would no longer be compatible with the existence of a stable equilibrium. However, one should stress that if temporary bubbles occur, they do not necessarily change fundamentally the relationship between the stock market valuation and investment. For example, Chirinko and Schaller (2001) explicitly address the impact of bubbles on corporate investment. Focussing on Japan, they demonstrate that bubbles will tend to stimulate (equity-financed) investment over and above the optimal level of investment based on the (unobserved) real Q.

Obviously, this adjusted measure will also take out the information relating to common developments in economic fundamentals in the two regions. As a result, we expect that using the adjusted  $\tilde{Q}_{it}$  measure will not only render significant those variables related to vertical location advantages – such as US technology variables – but might also affect the significance of euro area technology variables. However, this approach should give us a much clearer understanding of the role of both technology variables and the Tobin's Q.

#### ***4.2 Ownership and location advantage variables***

While discussing the data for the explanatory variables, it is useful to show how the respective variables enter the OLI-framework as a way of highlighting the contribution of this paper to the existing literature. Considerable emphasis is given to knowledge-related variables in the discussion of both ownership and location advantages, while internationalisation advantages are given less attention, as the latter typically originate from information imperfections related to knowledge transfers.

Ownership advantages usually originate from the presence of firm-specific assets ( $P_t$  in the model). In practice, such assets could, for example, be related to technological or

marketing capabilities. In the present paper we focus on the importance of firm-specific assets in the form of technological capabilities. More specifically, we use data on patents granted to euro area firms – obtained from the US Patents and Trademark Office (USPTO) as they reflect private knowledge (henceforth referred to as  $PAT_{it}$ ).<sup>14</sup>

The location advantages are often linked to firms' desire to locate close to the market they wish to supply. The *advantage* of locating close to the market increases with the information flows across affiliates. Following Portes and Rey (2002), the overall flow of information between countries is measured by the ratio of the volume of bilateral telephone traffic – obtained from the International Telecommunication Union (ITU) – and the corresponding euro area country GDP ( $IC_{it}$ ). The inverse of this ratio could be also interpreted as a measure of transaction costs.

Traditionally, vertical FDI (leading to the international fragmentation of production processes) has been associated with the persistence of significant factor cost differentials. However, it seems unlikely that the rapid increase in euro area FDI to the United States is driven by the desire to exploit factor cost differentials. As highlighted previously, the notion of vertical FDI has been extended in order to account for quality-seeking FDI (or 'technology sourcing'). Instead of "cost-reducing" FDI, firms might engage in FDI in order to acquire new technologies which could increase the productivity of the firms as a whole (Kogut and Chang, 1991; Neven and Siotis, 1996). Indeed, often cross-border M&A activities occur such that the technology of the involved firms is made available to all affiliates. One might argue that euro area FDI to the United States may have been partly motivated by the desire to "internalise" the stock of US knowledge-capital, which is considered to be one of the main drivers behind the strong performance of the US economy during the second half of the 1990s.<sup>15</sup>

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<sup>14</sup> See Griliches (1990) for a discussion of patents as economic indicators.

<sup>15</sup> The number of patents granted to US firms has increased at an accelerating pace over the last two decades in the "New Economy" sectors as well as in the economy as a whole. Over the period 1995-2000, the number of

To account for “vertical” location advantages, we employ a proxy for the pool of knowledge-capital present in the US economy; that is, expenditure on R&D in the United States ( $RD_{US,t}$ ), obtained from the US National Science Foundation (NSF). Figure 5 shows the strong rise during the second half of the 1990s in both US R&D expenditure and the share of US patents in high-tech sectors. Therefore, in order to capture the increasing importance of high-tech sectors in terms of technological capabilities and the associated compositional change in FDI towards these sectors, we also use as an alternative measure the number of patents granted to US firms in high-tech sectors relative to the total number of patents granted to US firms ( $HT_{US,t}$ ).

*[Insert Figure 5, here]*

#### ***4.3 Other variables and empirical specification***

The real exchange rate is defined in the model as the bilateral real exchange rate between the United States and the corresponding euro area countries ( $RER_{it}$ ).

Relative interest rates are added to capture the relative cost of capital ( $RI_{it}$ ). The higher the cost of capital in the euro area relative to the United States, the lower will be the level of investment of euro area firms in the United States (Barrell and Pain, 1997). We also add relative unit labour costs, which are defined as wages divided by labour productivity ( $RC_{it}$ ), to capture differences in the real cost of labour. As such, relative unit labour costs could both be a proxy for cost-reducing as well as for quality-seeking (i.e., higher productivity) FDI.

As the dependent variable is the absolute real value of the stock of FDI one should account for the market size of the source country. Therefore, in addition to the structural variables discussed so far, GDP of the home country ( $GDP_{it}$ ) is also included. For a more detailed

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patents increased by 53% in the whole economy and by 101% in the “New Economy” sectors. Over the period 1995-1999 total expenditure on R&D in the United States increased by 31% while in the “New Economy” sectors this amounted to 42%.

description of the data sources, and the derivation of the various variables, the reader is referred to the Appendix.

In summary, the following specification is estimated by pooling the data across either eight or, including the Netherlands, nine euro area countries for the period 1980-2001:<sup>16</sup>

$$(9) \quad \ln FDI_{it} = \alpha_1 + \alpha_2 FDI_{it-1} + \alpha_3 \ln GDP_{it} + \alpha_4 \ln PAT_{it} + \alpha_5 \ln RER_{it} + \alpha_6 \ln RI_{it} + \alpha_7 \ln IC_t + \alpha_8 \ln \tilde{Q}_{it} + \alpha_9 \ln RC_{it} + \alpha_{10} \ln TECH + \varepsilon_{it},$$

where

$FDI_{it}$  = real stock of euro area FDI in the United States,

$GDP_{it}$  = real euro area GDP,

$PAT_{it}$  = euro area patents,

$RER_{it}$  = real bilateral exchange rate,

$RI_{it}$  = relative cost of capital,

$IC_t$  = information flows,

$\tilde{Q}_{it}$  = "adjusted" Tobin's Q,

$RC_{it}$  = relative unit labour costs,

$TECH$  = various proxies for US technology such as

$R \& D$  activities in US manufacturing ( $RD_{US,t}$ ) or

the number of patents granted to US firms in high-tech sectors ( $HTU_{US,t}$ ) or

the US stock market index ( $SMI_{US,t}$ ).

First, we estimate equation (9) with the "adjusted" Tobin's Q measure ( $\tilde{Q}_{it}$ ); second, we re-estimate equation (9) by replacing ( $\tilde{Q}_{it}$ ) with the "unadjusted" measure ( $Q_{it}$ ). If the measures of Tobin's Q are statistically significant, we expect that the technology variables will be significant and positively signed when we include ( $\tilde{Q}_{it}$ ), but statistically insignificant when we replace ( $\tilde{Q}_{it}$ ) with ( $Q_{it}$ ).

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<sup>16</sup> Greece, Luxembourg and Portugal were excluded due to data limitations.

## 5. Empirical results

The model was estimated using LSDV. Although it is well known that the least squares dummy variables (LSDV) estimator yields biased results in dynamic panels with finite T (Nickell, 1981),<sup>17</sup> in the present case the LSDV estimator will still provide reasonable results as T is relatively large.<sup>18</sup>

Before discussing the results obtained from the estimation of our theoretical model, it is useful to develop a benchmark model of FDI based on traditional specifications adopted in the existing literature. As such, the benchmark model allows us to assess the value-added of the theoretical model developed in this paper once Tobin's Q is included. We also experiment with different technology variables in order to obtain a more detailed understanding of the role of different US technological developments in explaining the surge in outward FDI from the euro area to the United States.

We begin with the benchmark model in equation (9) but excluding the Tobin's Q measure. The Netherlands are initially dropped from the sample, because of its suspected role of this country as a hub for multinational enterprises. The results are shown in Table 1 (regressions 1 and 2) and confirm the idea that firm-specific assets are an important

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<sup>17</sup> The bias results from the correlation between the lagged dependent variable and the transformed residuals. Nickell (1981) shows that the lagged dependent variable is biased towards zero, but that the bias decreases in T and disappears when T goes to infinity.

<sup>18</sup> For example, Judson and Owen (1999) compare the bias of six different estimators of dynamic panel data models: the OLS estimator, the LSDV estimator, a corrected LSDV estimator as proposed by Kiviet (1995), two GMM estimators suggested by Arellano and Bond (1991), and the IV techniques used by Anderson and Hsiao (1981). Their findings are that the LSDV estimator performs just as well, or better than the majority of the alternatives as T increases. In addition, Kiviet (1995) notes that although the LSDV estimator is biased, its standard deviations are very small compared to different IV-estimators. Therefore, on the basis of the MSE-criterion (efficiency versus bias), Kiviet argues that LSDV may be preferable to alternative estimators.

determinant of FDI (i.e. euro area patents,  $PAT_{it}$ ).<sup>19</sup> The positive and significant effect for expenditure on R&D in the US suggests that the presence of knowledge-capital plays an important role in attracting euro area investors. The sign on the real exchange rate is negative as expected, but not always significant. Relative real interest rates are negative, but insignificant in all specifications. The statistical significance of other variables generally improve when the relative interest rate variable is dropped (regression 2). Telephone traffic relative to euro area GDP is positively signed and statistically significant, indicating that FDI increases with the flow of information. Relative unit labour costs are positive as expected, but only weakly significant. Meanwhile, home country GDP is positive and significant. In sum, the results obtained for the benchmark model are in line with our expectations, although not all variables are found to be strongly significant.

*[Insert Table 1, here]*

Regressions 3-5 of Table 1 then add the adjusted Tobin's Q ( $\tilde{Q}_{it}$ ) to the benchmark model. As expected, adjusted Tobin's Q is positive and statistically significant at the 1% significance level. All in all, the investment climate in the euro area countries – as proxied by  $\tilde{Q}_{it}$  – is found to affect the level of euro area investment abroad. In addition, allowing for the impact of  $\tilde{Q}_{it}$  in the euro area improves the overall performance of the model, which suggests that models of FDI that do not account for the investment climate in the home country could be mis-specified.

The results are basically the same for most of the variables if the Netherlands are included in the sample (see Table 2), except for euro area GDP, which is generally found statistically insignificant. To a certain extent, this result might capture the idea that the

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<sup>19</sup> A proxy for the market size of the United States was initially included, but the variable proved insignificant. The variable was subsequently omitted because of the collinearity with other economic aggregates (see also Culem, 1988).

Netherlands is a “hub” for multinational enterprises. In other words, the relative small size of the Netherlands together with large FDI outflows from this country to the United States might bias the panel results on euro area GDP.

*[Insert Table 2, here]*

Table 3 shows the results using the unadjusted Tobin’s Q. These confirm the role of the valuation of euro area firms as an important variable for explaining euro area FDI to the United States. Interestingly, comparing the results obtained with the adjusted Tobin’s Q measure ( $\tilde{Q}_{it}$ ) reveals that the point estimate for Tobin’s Q is very similar. Most importantly and, as expected, euro area patents and the US technology variables are no longer significant, which is consistent with the theoretical framework. All in all, the results of Tables 1-3 suggest that:

- The investment climate in the euro area, as proxied by adjusted Tobin’s Q, seems to add further explanatory power in addition to the information provided by the variables included in the traditional OLI-framework (see Table 2).
- Stock market developments, as proxied by unadjusted Tobin’s Q, adequately capture vertical location advantages (i.e. Table 3 shows that the unadjusted Tobin’s Q makes the technology variables insignificant).

*[Insert Table 3, here]*

In the rest of this section, we focus on the results of regressions 3-5 in Table 1. Euro area firm-specific assets measured by patents are found to play an important role in explaining euro area FDI to the United States. Also, Barrel and Pain (1997) use patents as a measure of ownership advantage to assess the relevance of firm-specific assets in the European context and find significant positive effects.

As expected the coefficient of the real exchange rate is negative and significant at the 1% significance level. A negative sign increases the value of the discounted stream of

expected profits in the United States in the home currency and will “therefore” encourage euro area FDI to the United States. The result is consistent with the analytical framework and with the findings by Cushman (1985) and Barrell and Pain (1996).<sup>20</sup> Another explanation for the negative sign of the exchange rate could be related to the link between intermediate inputs and FDI. Recent data show that euro area export values of intermediate inputs to the United States represent almost 50% of euro area export values of goods to the United States. In other words, euro area affiliates of multinational enterprises in the United States might have been using intermediate inputs exported to them by their parent companies in the production processes. An appreciation of the US dollar would make the purchase of these inputs cheaper and encourage further FDI to the United States, thereby, offering another explanation for the negative coefficient between FDI and the real exchange rate.

Bilateral telephone traffic relative to euro area GDP is found to be positively and significantly related to euro area FDI to the United States suggesting that an increase in information flows has a positive impact on euro area FDI.

Relative unit labour costs are found to have a positive and significant effect on euro area outward FDI to the United States. Intuitively, it does not seem to be realistic that euro area firms engage in FDI to the United States in order to save on labour costs, so a more feasible interpretation might be that the significance of the relative unit labour costs term is being driven by developments in labour productivity differentials.

The R&D variable, a proxy for vertical location advantages, has a positive sign and is statistically significant (regression 3), which is taken as evidence that the presence of knowledge-capital in the US economy attracts euro area FDI. This result complements previous findings by Kogut and Chang (1991), who focus on Japanese FDI in the United

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<sup>20</sup> Conversely, Klein and Rosengren (1994) find a positive and significant relationship between FDI and the exchange rate, when the relative stock market index is employed as a regressor.

States, and Neven and Siotis (1996), who found that expenditure on R&D in Europe is an important determinant for European inward FDI from the United States and Japan.

In terms of US technology, Figure 5 showed that much of US inward FDI was concentrated in high-tech sectors. Therefore, we also consider the relative importance of the new economy sectors based on a measure of US patent applications (i.e. the number of US patents in high-tech sectors relative to the total number of US patents).<sup>21</sup> The high-tech patents share variable is found to be positively signed and statistically significant (regression 4), which is consistent with the stylised facts. This variable is also capturing the compositional change towards high-tech sectors in euro area FDI to the United States as shown in Figure 4. Finally, euro area GDP is found to be positive and statistically significant.

In principle, the empirical model could be criticised as it employs measures of current technology in the United States, rather than a proxy for the (discounted) future values of the US stock of knowledge ( $\int K_s^j$ ). As a robustness check, we replace the US technology-variable with the US stock market index, which is a proxy for the discounted stream of future profits in the US economy and, therefore, a proxy for  $\int K_s^j$ . The US stock market index ( $SMI_{US,t}$ ) is positively signed and statistically significant (regression 5). Interestingly, the coefficients of the other variables, including the adjusted Tobin's Q, remain similar to the previous specifications and are all significant. In order to provide a broad summary, one might argue that all of the US technology variables may, in various ways, be related to US productivity developments – therefore, one could interpret all of the US technology variables, as well as relative unit costs (which includes productivity), as representing productivity effects.

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<sup>21</sup> We used patent data rather than R&D data for the share of US patents in high-tech sectors as the patent data allow a more detailed breakdown into high- and low-tech sectors.

A possible criticism to the empirical analysis is related to the spurious regression problem, as most of the employed variables are non-stationary and we estimate the model in terms of levels.<sup>22</sup> However, when estimating in levels, spurious regression may be a far less important problem in panel estimation compared to time series estimates. For example, Phillips and Moon (1999) show that for panels with large (T and N) the fixed effects estimator consistently measures a long-run effect even when both the variables and the error term are I(1). This is because the covariance between the I(1) regressor and the I(1) error term, which produces the spurious regression in time series, is much weaker in panels because of the averaging across independent groups. Nevertheless, to ensure that a spurious regression has not been estimated, we test whether the residuals of the specifications are stationary processes. The multivariate augmented Dickey-Fuller (MADF) test of Taylor and Sarno (1998), and the Levin-Lin (2002) and Im, Pesaran and Shin (2003) tests for unit roots strongly reject the null hypothesis that the residuals of the panel regressions are I(1) (see Table 4). The residuals of the LSDV estimates are stationary and, therefore, the LSDV results are not spurious.

*[Insert Table 4, here]*

## **7. Conclusion**

The literature on domestic investment and FDI has developed in a somewhat separate manner. The present paper represents a first step at bringing together elements of these two strands of literature by focussing on the long-term determinants of euro area FDI to the United States during the period 1980-2001. The theoretical model developed in this paper essentially

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<sup>22</sup> In the context of I(1) variables, an alternative possibility is to use the cointegration approach (Kao, 1999; Pedroni, 1999). However, given the large number of variables employed and the relative size of T and N, it was deemed that the cointegration approach was inappropriate for our analysis.

incorporates the traditional FDI model based on the OLI-framework within a model of investment with convex adjustment costs, i.e. the Q-model of investment.

The empirical results, which are based on a dynamic specification estimated using a fixed effects estimator, substantiate the theoretical predictions that the investment climate in the euro area, as reflected in Tobin's Q, turns out to be an important explanatory variable of euro area FDI to the United States. Furthermore, Tobin's Q, measured in the paper by stock market valuation indices, seems to add further explanatory power to FDI equations in addition to the information provided by the traditional variables included in the OLI framework.

To disentangle the effects of technology on FDI, we have adjusted the euro area stock market indices by regressing them on the US stock market index. The retrieved residuals were then used as our measure of the "adjusted" Tobin's Q. By so doing, however, we correct not only for positive spillovers from US firms to euro area multinational enterprises (which capture vertical location advantages) and for excessive correlation of stock markets, but also for comovement of other economic fundamentals between the two regions. In accordance with the theoretical framework, when the adjusted Tobin's Q measure is employed, several technology variables typically used in the OLI framework to capture ownership and location advantages become significant, while they are insignificant when using the unadjusted Tobin's Q.

Moreover, the volume of bilateral telephone traffic relative to euro area GDP was used to account for the importance of information flows in explaining FDI, while the negative sign of the real exchange rate was interpreted as representing the higher expected value of repatriated profits when expressed in the home country currency.

In summary, according to the OLI-Tobin's Q combined framework proposed in this study, euro area patents (ownership advantage), various variables related to productivity developments in the United States (location advantage), the volume of bilateral telephone

traffic to the United States relative to euro area GDP (location advantage), Tobin's Q and the real exchange rate (capital gains) all have the expected signs in line with our priors and are statistically significant.

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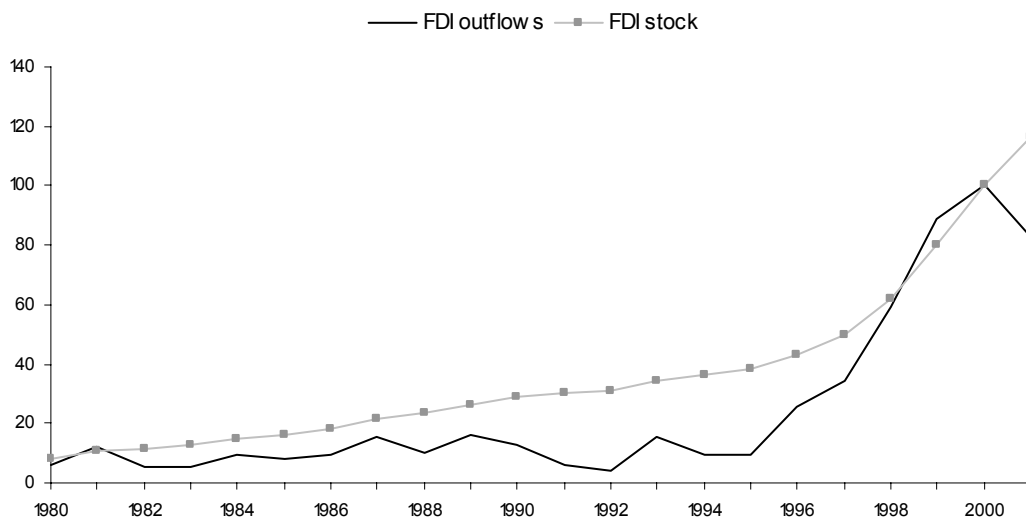
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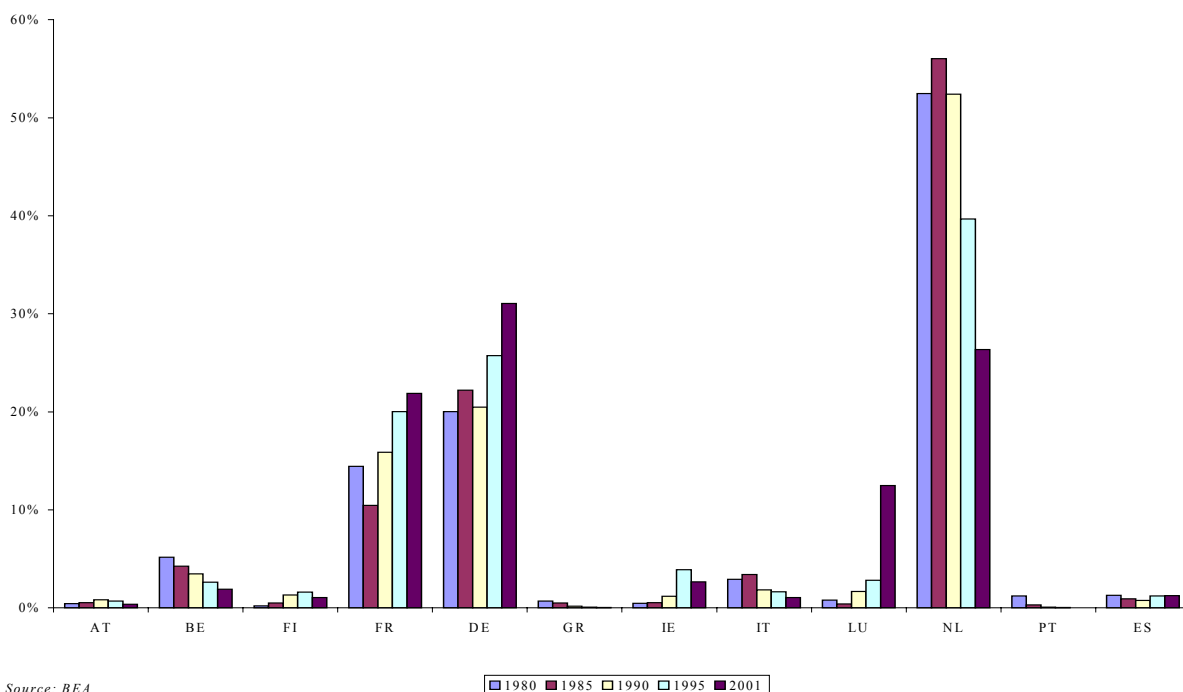
**Figure 1: Euro area stock and outflows of FDI to the United States**

(Indices: 2000=100, 1995 constant prices)



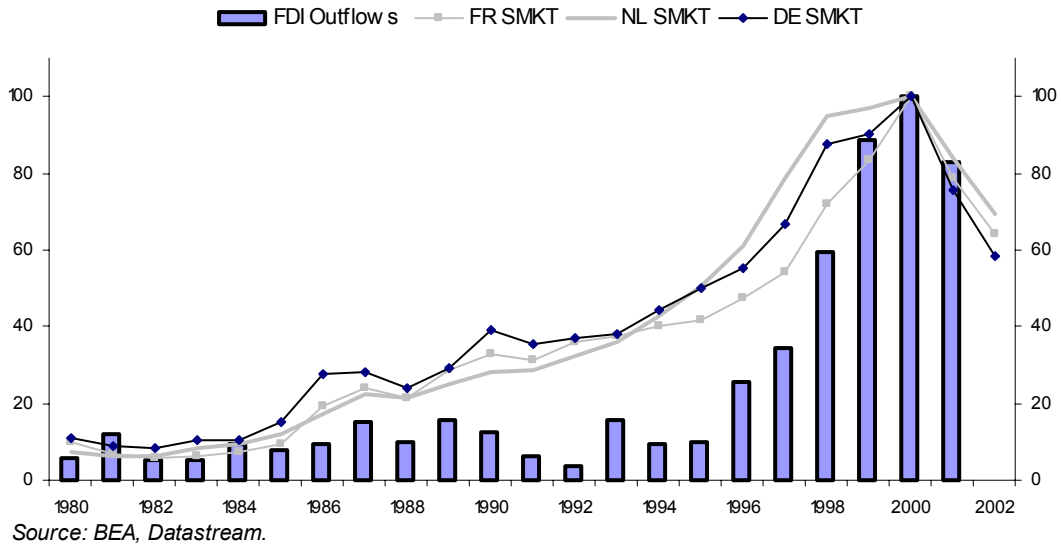
Source: Authors' calculations based on BEA nominal data.

**Figure 2: FDI in the United States for each euro area country expressed as a share of total euro area FDI to the United States**



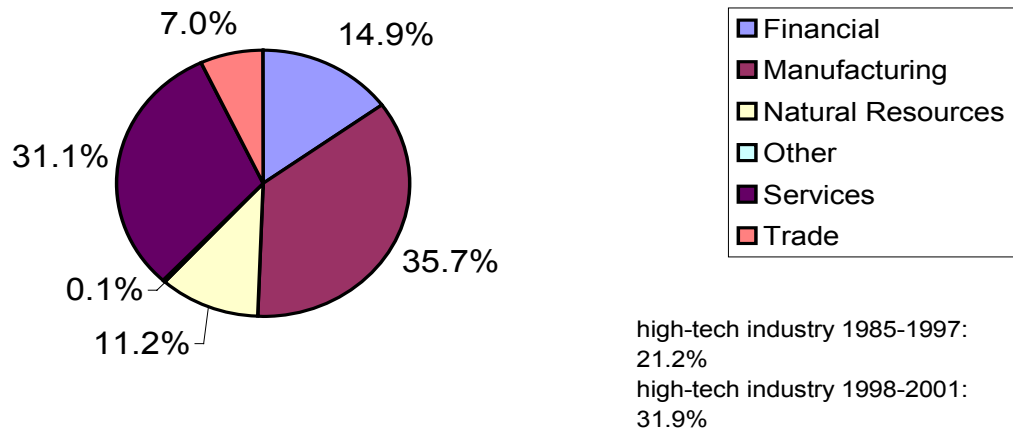
Source: BEA

**Figure 3: Euro area real FDI outflows to the United States and stock markets in three major euro area countries**  
(Indices: 2000=100)



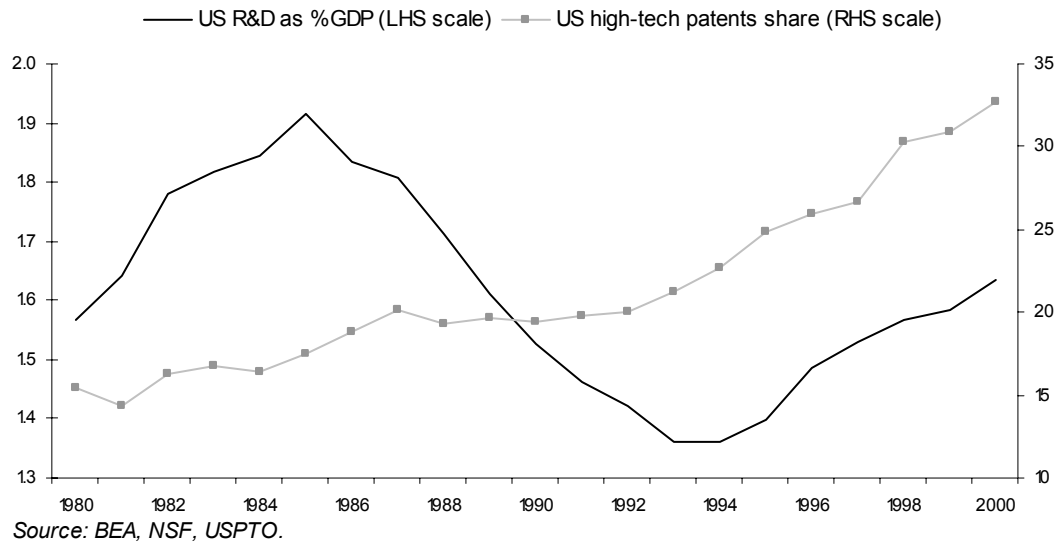
**Figure 4: Sectoral distribution of euro area Mergers and Acquisitions in the US**

**Euro Area M&A in the US by Industry**  
(% of total)



Source: Thomson

**Figure 5: US R&D expenditure as a percent of GDP and  
US high-tech patents as a percentage of total US patents**



**Table 1: The determinants of euro area FDI to the United States**  
(using adjusted Tobin's Q; excluding the Netherlands)

	OLI		OLI plus Tobin's Q		
	(1)	(2)	(3)	(4)	(5)
FDI <sub>t-1</sub>	0.82 (16.5) ***	0.82 (23.0) ***	0.81 (24.2) ***	0.82 (26.2) ***	0.82 (27.3) ***
GDP <sub>it</sub>	0.29 (2.22) **	0.28 (2.07) **	0.34 (2.52) **	0.31 (2.28) **	0.27 (2.11) **
PAT <sub>it</sub>	0.19 (1.76) *	0.20 (2.23) **	0.21 (2.46) **	0.17 (2.19) **	0.16 (1.99) **
RER <sub>it</sub>	-0.16 (-1.55)	-0.17 (-1.97) **	-0.26 (-2.68) ***	-0.32 (-3.76) ***	-0.31 (-3.72) ***
RI <sub>it</sub>	-0.03 (-0.26)	-	-	-	-
IC <sub>it</sub>	0.08 (1.96) **	0.09 (1.90) *	0.10 (2.98) ***	0.10 (2.73) ***	0.10 (2.65) ***
$\tilde{Q}_{it}$	-	-	0.11 (3.93) ***	0.13 (4.90) ***	0.14 (4.68) ***
RC <sub>it</sub>	0.71 (1.60)	0.68 (1.54)	0.90 (2.21) **	0.87 (1.99) **	0.81 (1.80) *
RD <sub>Ust</sub>	0.33 (1.99) **	0.35 (2.73) ***	0.31 (2.51) **	-	-
HT <sub>Ust</sub>	-	-	-	0.25 (2.29) **	-
SMI <sub>Ust</sub>	-	-	-	-	0.10 (2.37) **
Constant	-5.83 (-3.31) **	-5.98 (-4.47) ***	-6.34 (-5.33) ***	-3.36 (-2.51) **	-3.52 (-2.84) ***
AR(1)	-0.48	-0.37	-0.591	-0.6892	-0.5084
N(0,1)	[0.60]	[0.71]	[0.554]	[0.491]	[0.611]
Number of observations	168	168	168	168	168

\*, \*\*, \*\*\* indicate 10%, 5% and 1% significance levels. Robust t-values in parentheses.

**Table 2: The determinants of euro area FDI to the United States**  
(using adjusted Tobin's Q; including the Netherlands)

	OLI		OLI plus Tobin's Q		
	(1)	(2)	(3)	(4)	(5)
FDI <sub>t-1</sub>	0.84 (18.5) ***	0.83 (22.6) ***	0.82 (23.8) ***	0.83 (26.1) ***	0.83 (26.8) ***
GDP <sub>it</sub>	0.22 (1.72) *	0.19 (1.34)	0.24 (1.67) *	0.22 (1.43)	0.18 (1.19)
PAT <sub>it</sub>	0.19 (1.86) *	0.20 (2.29) **	0.22 (2.47) **	0.18 (2.15) **	0.17 (1.96) *
RER <sub>it</sub>	-0.13 (-1.36)	-0.15 (-1.85) *	-0.23 (-2.43) **	-0.29 (-3.46) ***	-0.28 (-3.39) ***
RI <sub>it</sub>	-0.07 (-0.72)	-	-	-	-
IC <sub>it</sub>	0.07 (1.64)	0.08 (1.69) *	0.10 (3.07) ***	0.09 (2.32) **	0.09 (2.26) ***
$\tilde{Q}_{it}$	-	-	0.10 (3.07) ***	0.12 (3.74) ***	0.12 (3.68) ***
RC <sub>it</sub>	0.64 (1.59)	0.54 (1.40)	0.75 (2.07) **	0.68 (1.74) *	0.63 (1.53)
RD <sub>Ust</sub>	0.29 (2.04) **	0.34 (2.84) ***	0.30 (2.62) ***	-	-
HT <sub>Ust</sub>	-	-	-	0.22 (2.23) **	-
SMI <sub>Ust</sub>	-	-	-	-	0.09 (2.20) **
Constant	-4.93 (-3.44) ***	-5.20 (-4.07) ***	-5.50 (1.19)	-2.69 (-1.80) *	-2.80 (-1.95) *
AR(1)	-0.5585	-0.2793	-0.4841	-0.5571	-0.3951
N(0,1)	[0.576]	[0.780]	0.628	[0.577]	
Number of observations	189	189	189	189	189

\*, \*\*, \*\*\* indicate 10%, 5% and 1% significance levels. Robust t-values in parentheses.

**Table 3: The determinants of euro area FDI to the United States**  
(using the unadjusted Tobin's Q)

	Excluding the Netherlands		Including the Netherlands	
	(1)	(2)	(3)	(4)
FDI <sub>t-1</sub>	0.78 (21.8) ***	0.78 (21.6) ***	0.81 (21.9) ***	0.81 (21.5) ***
GDP <sub>it</sub>	0.33 (2.68) ***	0.34 (2.79) ***	0.18 (1.14)	0.20 (1.21)
PAT <sub>it</sub>	0.11 (1.44)	0.10 (1.46)	0.15 (1.69) *	0.13 (1.55)
RER <sub>it</sub>	-0.31 (-3.72) ***	-0.31 (-3.76) ***	-0.23 (-2.27) **	-0.26 (-3.19) ***
IC <sub>it</sub>	0.13 (3.72) ***	0.13 (4.05) ***	0.10 (2.54) **	0.10 (2.75) ***
Q <sub>it</sub>	0.14 (3.11) ***	0.15 (4.57) ***	0.10 (1.93) *	0.11 (2.83) ***
RC <sub>it</sub>	0.99 (2.35) **	0.98 (2.30) **	0.66 (1.70) *	0.63 (1.53)
RD <sub>Ust</sub>	0.05 (0.27)	-	0.11 (0.63)	-
HT <sub>Ust</sub>	-	0.0 (0.02)	-	0.01 (0.08)
Constant	-3.85 (-2.81) ***	-3.58 (-2.98) ***	-3.24 (-2.30) **	-2.54 (-1.66) *
AR(1)	-0.3177	-0.3096	-0.1180	-0.081
N(0,1)	[0.751]	[0.757]	[0.906]	[0.935]
Number of observations	168	168	189	189

\*, \*\*, \*\*\* indicate 10%, 5% and 1% significance levels. Robust t-values in parentheses.

**Table 4: Unit root tests on the residuals**  
(using adjusted Tobin's Q; excluding the Netherlands)

		OLI regression (2)	OLI plus Tobin's Q regression (3)
<i>Deterministic trend</i>	<i>Lags</i>	<i>Im-Pesaran-Shin t-statistic (P-value)</i>	<i>Im-Pesaran-Shin t-statistic (P-value)</i>
Constant	0	-8.6 (0.000)	-8.8 (0.000)
	1	-6.1 (0.000)	-6.1 (0.000)
	2	-4.0 (0.000)	-4.2 (0.001)
Constant and trend	0	-8.9 (0.000)	-9.1 (0.000)
	1	-6.5 (0.000)	-6.7 (0.000)
	2	-4.4 (0.000)	-4.5 (0.000)
		<i>Levin-Lin t-statistic (P-value)</i>	<i>Levin-Lin t-statistic (P-value)</i>
Constant	0	-8.9 (0.000)	-9.2 (0.000)
	1	-6.1 (0.000)	-6.2 (0.000)
	2	-2.8 (0.003)	-3.0 (0.001)
Constant and trend	0	-9.4 (0.000)	-9.5 (0.000)
	1	-6.4 (0.000)	-6.4 (0.000)
	2	-2.5 (0.006)	-2.5 (0.006)
		<i>MADF t-statistics (5% critical values)</i>	<i>MADF t-statistics (5% critical values)</i>
Constant	1	181.4 (38.9)	187.6 (38.9)
	2	124.2 (41.7)	130.2 (41.7)

## Data appendix

All variables are in logs.

FDI <sub>it</sub>	The real stock of FDI of country <i>i</i> in the US at time <i>t</i> calculated as the cumulative sum of real flows plus the real benchmark stock of FDI in 1980 (deflated by the national GDP deflator). <u>Source:</u> BEA ( <a href="http://www.bea.gov">www.bea.gov</a> ).
GDP <sub>it</sub>	Real euro area country GDP based on gross domestic product at current prices, deflated by the national GDP deflator. <u>Source:</u> European Commission (DG ECFIN).
PAT <sub>it</sub>	5-Year moving average of patents granted in the US to euro area firms in country <i>i</i> . <u>Source:</u> USPTO.
RER <sub>it</sub>	The real bilateral exchange rate as obtained by multiplying the nominal exchange rate expressed in euro area currencies by the ratio of the GDP deflator at home and that in the United States. <u>Source:</u> BIS, IMF.
RC <sub>it</sub>	The ratio of real unit labour costs in the euro area over real unit labour costs in the US. Real unit labour costs based on nominal unit labour costs, total economy, deflated with national GDP deflator (1995=100). <u>Source:</u> European Commission (DG ECFIN).
RI	Relative long-term real interest rate measured by the ratio of euro area real interest rate over US real interest rate based on the nominal long term interest rate (OECD) and the GDP deflator. <u>Source:</u> OECD.
IC <sub>it</sub>	Lagged volume of bilateral telephone traffic as proxy for information costs divided by real euro area country GDP. Number of total minutes called abroad for each source country are available for 1980-2000 from the International Telecommunications Union. Bilateral telephone traffic with the United States is only available for the period 1991-2000 for a number of countries. In the case where no data on the volume of bilateral telephone traffic were available, total telephone traffic was used in combination with the ratio of bilateral telephone traffic over total international telephone traffic. The ratio was assumed constant over time. In the case that no bilateral data at all were available the ratio of a 'similar' country was used (BE=LUX and NL; FR=IT; UK=IRE; ES=PRT). Although this procedure is far from perfect (and responsible for excessively high values for Ireland), it is better than using simply total international telephone traffic. Note that with LSDV time-invariant effects are wiped out. As a result the coefficients will be unaffected. <u>Source:</u> ITU.

$Q_{it}$	<p>Stock market indices were obtained from Datastream Global Indices and Morgan Stanley. These indices are based on a representative sample of stocks in each market in order to make them internationally comparable. Tobin's Q is measured by the stock market index deflated by the corresponding national GDP deflator.</p> <p><u>Source:</u> Thomson Datastream, Morgan Stanley.</p>
$\tilde{Q}_{it}$	<p>The real euro area stock market indices are regressed on the real US stock market index. The retrieved residuals are defined as "adjusted" Tobin's Q.</p>
$RD_{US,t}$	<p>Real stock of manufacturing R&amp;D in United States measured as real current expenditure on R&amp;D.</p> <p><u>Source:</u> NSF, OECD.</p>
$HT_{US,t}$	<p>The lagged ratio of number of patents granted in the United States to US firms in high-tech sectors (sectors US SIC 357 and US SIC 365-67) over total number of patents granted in the United States to US firms.</p> <p><u>Source:</u> USPTO.</p>