FOREIGN DIRECT INVESTMENT AND EXCHANGE RATE UNCERTAINTY IN IMPERFECTLY COMPETITIVE INDUSTRIES.

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Abstract: This paper investigates the relationship between exchange rate uncertainty and the location of US foreign direct investment in Europe. We adopt a mean-variance approach to the standard q theory of investment in order to highlight the impact of exchange rate volatility and exchange rate correlation on investment. A firm concerned with both maximizing profits and minimizing risk would exploit any correlation between exchange rate movements to reduce the variance of its total profit. We estimate US foreign investment in the UK and in Continental Europe in a panel of seven manufacturing industries. Our results show that US firms investing in Europe tend to be risk-averse and decrease their investments as exchange rate volatility rises. Market power does not seem to reduce the effects of exchange rate volatility on FDI. We found strong evidence that that the UK is the preferred European location for US investors, since an increase in the correlation between the sterling dollar exchange rate and the euro dollar exchange rate tends to relocate US investment from the Euro Zone to the UK.

1 Introduction

Recent empirical research on foreign direct investment and exchange rate uncertainty has highlighted the ambiguous effects of exchange rate volatility on FDI. Cushman (1985) and Cushman (1988) found evidence of a positive relationship between US FDI and exchange rate uncertainty, whereas Bénassy-Quéré, Fontagné and Lahrèche-Revil (2001) show that exchange rate volatility in emerging economies has a negative impact on OECD outward FDI to these countries. Cushman (1985) shows that exchange rate risk may increase direct investment bilateral flows between the US and Canada, France, Germany, Japan and the UK, whilst Cushman (1988) finds an analogous relationship between exchange rate risk and inward US FDI. In both papers, Cushman develops a mean-variance framework in which a firm's utility is a positive function of expected profit and a negative function of the variance of profit. The latter derives solely from exchange rate risk. FDI is mainly determined by the host country's relative factor cost competitiveness, which is influenced by exchange rate volatility. The importance of exchange rate risk depends on whether the firm produces domestically or abroad, and on the share of imported inputs in produc-

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tion. Although Cushman attempts to apply conventional portfolio theory to the analysis of US foreign direct investment, none of the models presented in Cushman (1985) and Cushman (1988) considers that a risk-averse firm would try to minimize the variance of its total profit by exploiting the correlation between exchange rate movements. Bénassy-Quéré, Fontagné and Lahrèche-Revil (2001) extend Cushman's work and investigate the role of exchange rate correlation on foreign direct investment from OECD countries into developing economies. In Bénassy-Quéré, Fontagné and Lahrèche-Revil (2001) the typical investing firm is a multinational producing abroad and exporting from there to the home country. Its location choice will be determined by the potential host relative competitiveness, which is proxied by the relative real exchange rate of the potential host against the investor's exchange rate. An increase in competitiveness is measured by the depreciation of the host country's currency. Their empirical analysis indicates that, irrespective of the sign of exchange rate correlation between alternative locations, inward FDI to one country decreases if the competitiveness of an alternative host rises.

In this paper, we investigate the role of exchange rate risk diversification as a determinant of the location of US FDI in Europe. We apply standard portfolio theory to the q theory of investment to show that risk-averse firms can reduce the negative impact of exchange rate fluctuations on their profits by diversifying their investment across locations. Unlike Cushman (1985), Cushman (1988) and Bénassy-Quéré, Fontagné and Lahrèche-Revil (2001), we focus exclusively on the impact of exchange rate risk on foreign direct investment and assume that firm-level specificities-e.g., competitive factor costs- are captured by the profits reported by affiliates. Bénassy-Quéré, Fontagné and Lahrèche-Revil (2001) and Cushman (1985) assume firms are perfectly competitive. On the contrary, we consider that firms are imperfectly competitive, since there is ample theoretical and empirical evidence that market power moderates the negative impact of exchange rate volatility on domestic investment. We are not aware of any analysis of the interaction between market power and exchange rate volatility in the case of inward or outward foreign direct investment, and thus extend the works of,among others, Campa and Goldberg (1995), Campa and Goldberg (1999) and Nucci and Pozzolo (2001).

Following this introduction, Section 2 presents the theoretical framework that will be estimated in Section 3, and discusses measures of industrial concentration. Section 3 shows the results of the panel data estimation. Section 4 concludes.

2 The model

A firm chooses investment in locations A and B to maximize the present value of its utility:

$$V_t = \int_0^{\infty} e^{-rt}[U(E[(\pi(.)], Var[\pi(.)]) - C(I_A, I_B) - I_A - I_B]dt \tag{1}$$

where $E[\pi(.)]$ and $Var[\pi(.)]$ are the expected value of profits and the variance of profits respectively. We assume the firm is risk-averse, so $U(E[\pi(.)], Var[\pi(.)])$ is increasing in the expected value of profits and decreasing in the variance of profits. r is the discount factor and is constant over time and identical in both countries. $C(I_A, I_B)$is the adjustment cost of capital. The profit function of the firm is given by $\pi(K_A, K_B, e_A, e_B)$.

The firm maximizes (1) subject to the following accumulation equations:

$$I_i = \frac{dK_i}{dt} \tag{2}$$

The solution to this maximization is obtained by forming the Hamiltonian:

$$\begin{gathered} H(U(\pi(.)), C(I_A, I_B), I_A, I_B) = e^{-rt}U(\pi(.)) - C(I_A, I_B) - I_A - I_B - \\ \lambda_A(t)(I_A) - \lambda_B(t)(I_A) \end{gathered} \tag{3}$$

The necessary conditions for the solution of the Hamiltonian are:

$$\frac{\partial H}{\partial \lambda_i} = \frac{dK_i}{dt} \tag{4}$$

$$\frac{\partial H}{\partial I_i} = 0 \tag{5}$$

$$-\frac{\partial H}{\partial K_i} = \frac{\lambda_i}{dt} \tag{6}$$

Let $\mu_i = \lambda_i e^{rt}$. From (5)

$$\mu_i = 1 + \frac{\partial C}{\partial I_i} \tag{7}$$

from (6)

$$\int \frac{\lambda_i}{dt} dt = \int e^{-rt} \frac{\partial U}{K_i} dt \tag{8}$$

for i=A,B. Integrating (8) results in

$$\lambda_i(t) e^{rt} = \int \frac{\partial U}{K_i} dt \tag{9}$$

Since $\mu_i = \lambda_i e^{rt}$ and substituting (9) in (7) we have

$$\int \frac{\partial U}{K_i} dt = 1 + \frac{\partial C}{\partial I_i} \tag{10}$$

i=A,B. We assume the cost of investment follows the specification given in Hayashi (1982)

$$C(I_A, I_B) = \frac{\gamma}{2}[(I_A - \mu)^2 + (I_B - \mu)^2] \tag{11}$$

Differentiating (11) with respect to K_i i=A,B and substituting in (10) yields

$$\int \frac{\partial U}{K_i} dt = 1 + \gamma(I_i - \mu) \tag{12}$$

Solving for I_i we obtain an expression for investment, which depends on the firms' utility $U(\pi(.))$

$$I_i = (\int \frac{\partial U}{K_i} dt - 1)\gamma^{-1} - \mu \tag{13}$$

At this stage we must specify a profit function for the investing firm. We consider that capital is a quasi-fixed cost, so that the cost-minimizing function $C_1^*(w_A, w_B, q_1^A, q_2^B, K_A, K_B)$ is a function of the capital stock in country A and country B. The nominal profit function of firm 1 in industry k, with plants in countries A and B, can thus be described as

$$\begin{aligned} \pi_{1,k}^* = & \max_{q_{1,k}^A, q_{1,k}^B} p^{A,k}(Q^{A,k}) q_{1,k}^A e_A + p^{B,k}(Q^{B,k}) q_{1,k}^B e_B \\ & - (w_A + K_A) e_A q_{1,k}^A - (w_B + K_B) e_B q_{1,k}^B \end{aligned} \tag{14}$$

where $q_{1,k}^i$ is output of a firm in industry k, producing in country i=A,B. $Q^{i,k}$ is the aggregate demand in country i in industry k, and is equal to the sum of production of firm 1 and firm 2 in country i. $Q^i = q_1^i + q_2^i$. e_i is the exchange rate in units of country i's currency per units of the investing firm's currency. So, the firm's profits are given in the currency of its home country. K_i is the stock of capital and is fixed in the short-run. w_i, i=A, B is the price of factors in country B's. We assume that industry k is oligopolistic. Firm 1 maximizes its profit making certain assumptions about the reaction of its competitors in the industry. These assumptions are summarized in the derivative of the demand function with respect to the aggregate demand, $\frac{\partial P(Q_i)}{\partial Q_i}$.

The first order conditions for firm 1 are:

$$\frac{\partial \pi}{\partial q_1^A} = p^{A,k}(Q^{A,k})(1 + \frac{q_1^A}{Q_A}\frac{1}{\epsilon_A})e_A - (w_A + K_A)e_A \tag{15}$$

$$\frac{\partial \pi}{\partial q_1^B} = p^{B,k}(Q^{B,k})(1 + \frac{q_1^B}{Q_B}\frac{1}{\epsilon_B})e_B - (w_B + K_B)e_B \tag{16}$$

ϵ_i is the elasticity of the aggregate demand in country i. In (15) and (16), $\frac{\partial P(Q_i)}{\partial Q_i}$ was multiplied by $Q_i/Q_iP(Q_i)$, which yields the inverse of the elasticity of the aggregate demand.

Solving (15) and (16) for $P(Q_i)$, and defining the market share of of firm 1 in country i as $s_i = \frac{q_i}{Q_i}$, gives

$$P(Q_i) = \frac{w_i + K_i}{1 + \frac{s_i}{\epsilon_i}} \tag{17}$$

Substituting (17) in the profit function gives the optimum profit given the capital stock

$$\begin{aligned} \pi^* = {} & (w_A + K_A)(1 + \frac{s_A}{\epsilon_A})^{-1} e_A q_{1,k}^{A*} + (w_B + K_B)(1 + \frac{s_B}{\epsilon_B})^{-1} e_B q_{1,k}^{B*} \\ & - (w_A + K_A)e_A q_{1,k}^{A*} - (w_B + K_B)e_B q_{1,k}^{B*} \end{aligned} \tag{18}$$

where the starred variables are the optimum outputs of firm 1 in country A and in country B.

Finally, we adopt a mean-variance specification for the firm's utility function $U(\pi)$, which reflects the assumption of risk aversion,

$$U(\pi(.)) = E[\pi(.)] - \phi Var[\pi(.)] \tag{19}$$

where E[.] and Var[.] are the expectation and the variance operators. Clearly, $U(.)$ varies positively with mean profits and negatively with the variance of profits. The derivative of $U(.)$ with respect to K_i in (13) is thus the derivative of the expected value of the profit minus the derivative of the variance of profits. This specification also has the advantage of highlighting the role of the correlation between the exchange rates of country A and country B. In effect, suppose a firm has a total amount of assets to be invested (K) that can be split between a number of foreign investments r_i (i=1,...,n). Suppose also that uncertainty is due to exchange rate risk (σ_i^2). If the firm chooses to invest w_i as a proportion of its assets in each country ($w_i < 1, \forall i, \sum w_i = 1$) then the total expected return on the firms assets will be

$$E[r] = \sum -i^n w_i E[r_i] \tag{20}$$

and the expected variance of the returns will be given by

$$\sigma^2 = \sum_1^n w_i^2 \sigma_i^2 + \sum_i^n \sum_j^n w_i w_j \sigma_{ij} \tag{21}$$

from which we obtain,

$$\sigma^2 = \sum_1^n w_i^2 \sigma_i^2 + \sum_i^n \sum_j^n w_i w_j \rho_{ij} \sigma_i^2 \sigma_j^2 \tag{22}$$

where ρ_{ij} is the correlation coefficient. A firm which is purely interested in maximizing expected profits should therefore invest only in the country or countries with the highest returns but a firm which is concerned with both maximizing profits and minimizing risk would exploit any correlation between returns which is less than one to reduce the variance of the total return. A correlation coefficient of 1 of course means that there are no benefits to diversification between the two regions and only the region with the higher return should receive any investment.

Given (19) and (18), $U(E[\pi(.)], Var[\pi(.)])$ can now be written as

$$U(.) = E[e_A \pi_1^{A*} + e_B \pi_1^{B*}] - \phi Var[e_A \pi_1^{A*} + e_B \pi_1^{B*}] \tag{23}$$

where $\pi^* = e_A \pi_1^{A*} + e_B \pi_1^{B*}$. Differentiating (23) with respect to K_i and substituting the result in (13) gives

$$I_i = (\int_0^\infty E[\frac{\partial \pi^*}{\partial K_i}] - \phi Var[\frac{\partial \pi^*}{\partial K_i}] dt - 1)\gamma^{-1} - \mu \tag{24}$$

where

$$E[\frac{\partial \pi^*}{\partial K_i}] = [(1+\frac{s_i}{\epsilon_i})^{-1} - 1]E[e_i]q^i_{1,k} \tag{25}$$

$$Var[\frac{\partial \pi^*}{\partial K_i}] = [(1+\frac{s_i}{\epsilon_i})^{-1}-1]^2\sigma_i^2 q^{i*2}_{1,k} + 2Cov(e_i ej)[(1+\frac{s_i}{\epsilon_i})^{-1}-1][(1+\frac{s_j}{\epsilon_j})^{-1}-1]q^i_{1,k}q^j_{1,k} \tag{26}$$

$\sigma_i^2 \equiv Var(e_i)$. It should be noted that the sign of the expression involving $Cov(e_i, e_j)$, depends on the sign of the exchange rate covariance. Here, we implicitly assume that the weight of investment in each location is $w_i = \frac{I_i}{\sum I_i}$. (26) can be related to (21) by noting that $\rho_{i,j} = \frac{Cov(e_i,e_j)}{Var(e_i)*Var(e_j)}$.

2.1 Comparative statics

The impacts on investment of exchange rate volatility and correlation between exchange rates can be shown by differentiating (24) with respect to the variance of e_i and the covariance of e_i and e_j.

$$\frac{\partial I_i}{\partial Var[e_i]} = -\phi\gamma^{-1}\int_0^\infty [(1+\frac{s_i}{\epsilon_i})^{-1} - 1]^2]q^2_{1,k,i}dt \tag{27}$$

where $q_{1,k,i}$ is the production of firm 1 of industry k in country i. (27) is clearly negative and unsurprising. Since we assume a risk- averse firm, volatility should have a negative impact on investment. More interesting is the fact that the negative impact of volatility is reduced when the firm's market power increases. To simplify notation, we replace the mark-up expression in (27) by its equivalent in terms of the Lerner index of market power. From (15), we can write

$$\frac{p_i - c_1}{p_i} = -\frac{s_1}{\epsilon_i} \tag{28}$$

The left-hand side of (28) is the Lerner index of market power, denoted L. Substituting L in (27) and differentiating with respect to L, we found

$$\frac{\partial I_i}{\partial Var[e_i]\partial L} = -2\phi\gamma^{-1}\int_0^\infty (1-L)^{-2}[(1-L)^{-1} - 1]q^2_{1,k,i}dt \tag{29}$$

which is also clearly negative. Finally, we show that the impact of exchange rate correlation on investment depends on the sign of the derivative of (24) with respect to $Cov(e_i, e_j)$.

$$\frac{\partial I_i}{\partial Cov[e_i e_j]} = -2\phi\gamma^{-1}\int_0^\infty [(1-L_i)^{-1}-1][(1-L_j)^{-1}-1]q_{1,k,i}q_{1,k,j}dt \tag{30}$$

Considering that $Cov(e_i, e_j) = \rho_{i,j}\sigma_i^2\sigma_j^2$, two cases can be characterised.

Case 1: $-1 \leq \rho_{i,j} < 1$. Risk diversification can be achieved by relocating investment from one country to the other, since exchange rates are either partially correlated or cancel each other.

Case 2: $\rho_{i,j} = 1$. Exchange rates are perfectly correlated. There is little possibility for risk diversification. Investment location will be determined by other factors, e.g. rate of return, market size, labour market conditions.

2.2 Measures of concentration

The most appropriate measure of a firm's market power is the Lerner index, which is given by the ratio of price less marginal costs over price. As marginal costs are not directly observable, a proxy for market power is generally used. Here, we use an industry-wide measure of market power, the market Lerner index, defined as the weighted sum of individual firm Lerner indices, the weights being their market shares. Assuming that firms engage in Cournot competition, the market Lerner index can be written as function of the Herfindalh index (H) and the demand elasticity,(η),

$$L = \frac{-H}{\eta} \tag{31}$$

Herfindahl Indices can be constructed from various measures of firm size, gross output per firm, value added per firm, number of employees per firm. We use the share of value added at factor prices per firm as a measure of firm size. Eurostat data on value added at factor prices are more complete than other measures of firm sizes. We construct a Herfindahl index for 7 two-digit industries in the European Union for 1995, the obly data point available. For this reason, we will assume in the empirical analysis of investment that the Herfindahl index is constant over time. Eurostat data for the UK were available from 1995 to 2000. We used the average over those five years as the constant Herfindahl Index for the UK

2.3 Measures of uncertainty

We have chosen a GARCH measure of exchange rate volatility. Since we are focusing on FDI to two distinct countries, we need to understand the conditional distribution of a group of two variables, the sterling dollar exchange rate and the euro dollar exchange rate. A number of studies have already extended the basic GARCH framework to a multivariate context so that we may consider complete conditional covariance matrices,

Table 1: Herfindahl index. UK. and European Union.

Industry	UK	European Union
Food and Kindred Products	0.30	0.16
Chemicals and Allied Products	0.24	0.24
Primary and Fabricated Metals	0.13	0.13
Machinery	0.14	0.15
Electrical and Electronic Equipments	0.19	0.24
Transportation Equipment	0.42	0.54
Other Manufacturing	0.14	0.14

Kraft and Engle (1982), Bollerslev, Engle and Wooldridge (1988), Hall, Miles and Taylor (1990),Hall and Miles (1992), and Engle and Kroner(1995). Let us consider a set of n variables Y that may be assumed to be generated by the following VAR process.

$$A(L)Y_t = e_t \tag{32}$$

This differs from a conventional VAR model as we assume that

$$E[e_t] = 0 \tag{33}$$

$$E[e_t e_t^{'}] = \Omega_t \tag{34}$$

so that the covariance matrix is time varying. We then make the standard ARCH assumption that this covariance matrix follows an autoregressive structure. Estimation of such a model is, in principle, quite straightforward as the log likelihood is proportional to the following expression.

$$l = \sum_{t=1}^{T} ln|\Omega_t| + e_t^{'}\Omega_t^{-1}e_t \tag{35}$$

and so standard maximum likelihood (or quasi maximum likelihood) procedures may be applied. If we define the VECH operator in the usual way as a stacked vector of the lower triangle of a symmetric matrix then we can represent the standard generalization of the univariate GARCH model as

$$VECH(\Omega_t) = C + A(L)VECH(e_t e_t^{'}) + B(L)VECH(\Omega_{t-1}) \tag{36}$$

where C is an (N(N+1)/2) vector and A and B are (N(N+1)/2)x(N(N+1)/2) matrices. This general formulation presents a couple of drawbacks. First,(36) rapidly produces huge

Table 2: Bivariate real exchange rate model.$e_{i,t} = D_{i1}e_{i,t-1} + D_{i2}e_{j,t-1} + \epsilon_t$, for $i \neq j = 1, 2$

Var	Coeff	Std. Error	t-Stat
D11	0.626276	0.253210	2.5
D12	0.942173	0.020272	46.4
D21	0.253396	0.156416	1.6
D22	0.956215	0.012994	73.5
A11	0.142521	0.101197	1.4
B11	0.001000	0.175105	0.0
C11	0.018854	0.001291	14.6
C12	0.011676	0.001640	7.1
C22	0.000003	0.001411	0.0
A22	0.640873	0.166676	3.8
B22	0.576504	0.097145	5.9

numbers of parameters as N rises. For instance, for 1 lag in A and B and a 5 variable system 465 parameters have to be estimated. So, beyond the simplest system (36) will almost certainly be intractable. Second, without fairly complex restrictions on the system the conditional covariance matrix cannot be guaranteed to be positive semi definite. Much of the literature has thus focused on finding a parameterization which is both flexible enough to be useful and yet is also reasonably tractable.

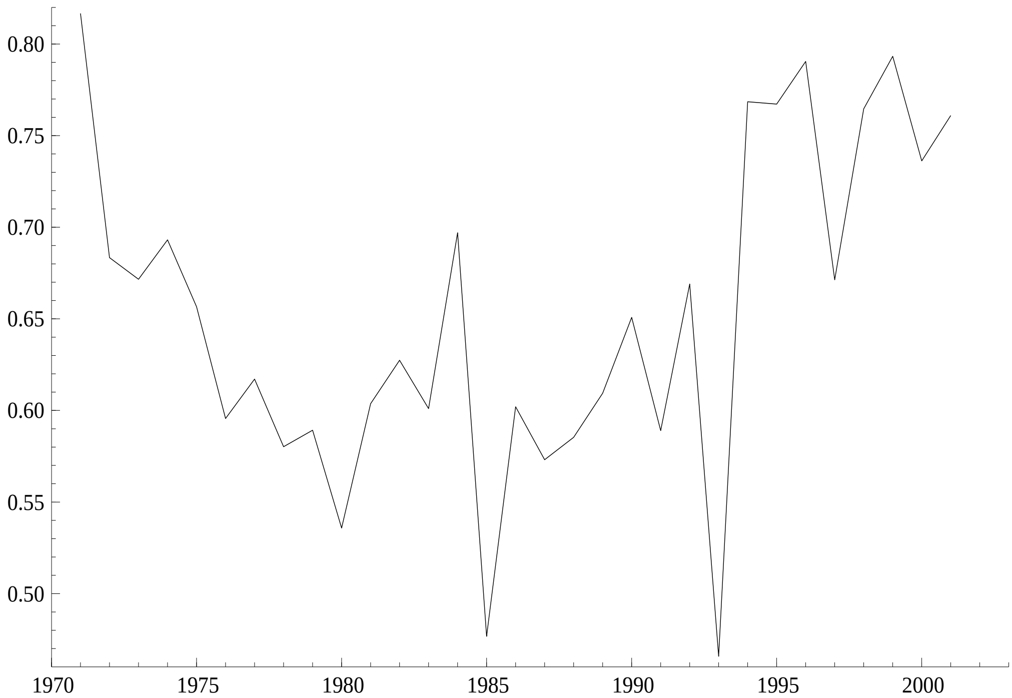
One of the most popular formulations was first proposed by Baba, Engle, Kraft and Kroner, sometimes referred to as the BEKK(see Engle and Kroner(1993)) representation, this takes the following form

$$\Omega_t = C'C + \sum_{i=1}^{q} A_i' e_{t-i} e_{t-i}' A_i + \sum_{j=1}^{p} B_{t-j}' \Omega_{t-j} B_{t-j} \tag{37}$$

This formulation guarantees positive semi definiteness of the covariance matrix almost surely and reduces the number of parameters considerably. We define a pair of simple first order autoregessions for the log of the real exchange rate, $e_{i,t}$ i=1,2, and estimate a bivariate BEKK model of the conditional covariance and the conditional correlation between the real dollar-sterling rate and the real dollar-euro rate. The A and B matrices are restricted to be diagonal, maximum likelihood estimation. Consumer price indices were used to obtain the real exchange rates. Results are presented in Table 2. D11 and D12 are the constant and lagged dependent variable coefficients in the sterling dollar equation and D21 and D22 are the corresponding coefficients in the euro dollar equation. A_{ij}, B_{ij} and C_{ij} are elements of the matrices defined in (37).

Figure (1) shows a positive correlation between the dollar-sterling and the dollar-Euro exchange rates over the whole sample period. This clearly indicates that variations in

Figure 1: Correlation between real sterling dollar and real euro dollar exchange rates. 1971-2001



both exchange rates tend to be in the same direction. These variations are considerable. Starting from an average of 60 per cent in the 1970s, the correlation drops to 40 per cent in 1981 before peaking at more than 80 per cent in 1986. From 1987 to 1996 the exchange rate correlation presented an upward trend before a plummeting to approximately 0 in 1998. The positive correlation between the dollar-sterling exchange rate and the dollar-Euro exchange rate does not indicate a complementarity between U.S. foreign direct investment in the UK and U.S. foreign direct investment in the Euro Area. Such a conclusion depends on the sign of the coefficient of the correlation in the econometric estimation of equation (24) above, which will be carried out in Section (3) below.

3 Econometric analysis

3.1 Data

Annual data from the U.S. Bureau of Economic Analysis (BEA) survey of US direct investment abroad were used in the empirical analysis. The countries covered are the UK and the following members of the single currency, Austria, Belgium, France, Germany and the Netherlands. This group of Euro Area countries had effectively fixed exchange rates over the period 1982-2000. They can therefore be treated as the same location and aggregated together. For the sake of simplicity they will be denoted "Euro Area" throughout the paper. Seven two-digit manufacturing industries were considered, Food and Kindred Products, Chemicals and Allied Products, Primary and Fabricated Metals, Machinery, Electrical and Electronic Equipments, Transportation Equipment, Other manufacturing. Data on direct investment by country and by industry are available only on a historical-cost basis and for foreign affiliates in which US firms have direct or indirect ownership or control of more than 10 per cent of voting securities. Year-to-year changes in the stock of FDI include net capital outflows between the U.S. parent and its affiliate, inter-company debt and reinvested earnings. Valuation adjustments, e.g., exchange rate adjustments, price changes and other capital gains and losses, are also included in year-to-year changes.

Net income reported by affiliates in year t divided by investment in the previous year was taken as a measure of the rate of return on investment in year $t-1$. Net income is gross profit net of local corporate taxes. Real data were obtained by deflating the original data by the U.S. Consumer Price Index. Data are available from 1982 to 2001. The sample period for estimation, however, was restricted to the period 1982-1998, since in 1999 a change in the industrial classification of Electrical and Electronic Equipments created a break in the series. This data set naturally calls for panel data analysis by 7 industries and over 18 time periods.

3.2 Results

Our theoretical framework suggests that the change in FDI into a location will depend upon the profitability of that location and the risks associated with it.[1] Adjustment to long run changes in driving variables such as profitability is unlikely to be immediate, and hence any model we estimate has to take into account the dynamics of adjustment. Following the shareholder's perspective on investment adopted in our theoretical specification, the long-run relationship includes the rate of return, the cost of capital, the exchange rate risk and the correlation between exchange rates. We estimate the following equation:

$$\begin{aligned}\Delta FDI_{i,k,t} = {} & \phi FDI_{i,k,t-2} + a_1 FDI_{j,k,t-2} + a_2 RR_{i,k,t-2} + a_3 RR_{j,k,t-2} + a_4 USLR_{t-2} + \\ & a_5 RRX_{t-2} + a_6 \sigma^2_{i,t-2} + a_7 \sigma^2_{j,t-2} + a_8 \rho_{i,j,t-2} + \\ & \bigtriangledown \left(FDI_{i,k,t}, FDI_{j,k,t}, RR_{i,k,t}, RR_{j,k,t}, USLR_t, RRX_t, \sigma^2_{i,t}, \sigma^2_{j,t}, \rho_{i,j,t}\right) + \gamma_{i,k} + u_{i,k,t} \end{aligned} \tag{38}$$

for $i \neq j=$ UK, Euro Area. $FDI_{i,k,t}$ is the log of real US FDI in industry k in location i, $RR_{i,k,t}$ the real rate of return reported by affiliates in industry k in location i. $USLR_t$ is the U.S. 10 years real interest rate and was included as a proxy for the cost of capital. RRX_t is the real sterling/ euro exchange rate. $\sigma^2_{i,t} \equiv var[e_{i,t}]$ is the GARCH estimate of the variance of the exchange rate in location i, e_i. $\rho_{i,j,t} \equiv corr[e_{i,t}, e_{j,t}]$ is the GARCH estimate of the correlation between the exchange rate in location i and the exchange rate in location j. $\gamma_{i,k}$ are the individual effects and $u_{i,k,t}$ is the error term. To simplify the notation of (38) we use $\bigtriangledown(FDI_{i,k,t}, FDI_{j,k,t}, RR_{i,k,t}, RR_{j,k,t}, USLR_t, RRX_t, \sigma^2_{i,t}, \sigma^2_{j,t}, \rho_{i,j,t})$

[1]This can be seen by differentiating (24) with respect to time.

to represent the dynamics of the variables in the brackets.

In (38) the lagged dependent variable also appears as explanatory variable. In this case, it has been shown that the error terms are correlated with the values of the regressors. Maximum-likelihood and generalised least-square estimators are biased when the number of individuals N is large and the number of time periods T short[2]. We thus adopt the generalized method of moments (GMM) developed by Arrellano and Bond (1991), who provide an efficient estimator of dynamic panels whith large N and short T. Estimation and hypotheses testing were conducted using PcGive10.0

We expect increases in the rate of return to have a positive impact on FDI. The estimated coefficient of RR_t should be positive. Other things equal, costlier capital tends to depress investment, so, the coefficient of $USLR_t$ should be negative. Since we assume firms are risk- averse, the coefficient of the relative exchange rate variance is expected to be negative. The implications of the sign of the coefficient of the correlation were presented in Section 2 above. The sign of the real sterling euro exchange rate is expected to be negative, or not significant. In effect, over the period 1982-2000, total sales of goods and services produced an average of 94 per cent of the profits of UK affiliates in manufacturing industries, of which 60 per cent were domestic sales. An average of 29 per cent of total sales was exported to all countries excluding the U.S. Although the BEA does not specify which European countries UK affiliates export to, an average of 85 per cent of exports by European affiliates was destined to the European Union. We can then infer that between 1982 and 2000, most of the exports of UK affiliates were bound to the European Union. If we assume that these exports amounted to 85 per cent[3], we can also infer that less than a quarter of the profits made by UK affiliates derive from their exports to the European Union.

The results reported in Table 3, column[1], are generally poor. The coefficient of $FDI_{uk,t-2}$, is only significant at the 10 per cent level, and the signs of several coefficients are not sensible. The rate of return in the UK should have a positive-rather than negative- impact on inward FDI in the UK. Analogously, the coefficient of $\sigma_{uk,t-2}$ should be negative, and not positive as reported in column [1], whereas the coefficient of $\sigma_{eu,t-2}$ should be positive. An increase in the volatility of the euro dollar exchange rate would probably make the UK more attractive then the EU for outward US investment. The results of column [1] indicate that the opposite would be more likely. The sign of the real cross-exchange rate in column [1] is positive, indicating that an increase in the sterling euro exchange rate should raise investment in the UK. The cost of capital, $USLR_{t-2}$ was not found significant.

$FDI_{eu,t-2}$ has a positive sign, suggesting that US firms may not regard Europe as a market segmented into Euro Area and non-Euro Area. A positive sign indicates that US firms increase their investment in the UK following an rise in FDI into the Euro Area. This result is consistent with the negative sign of the rate of return in the Euro Area ($RR_{eu,t-2}$), as it indicates that an increase in the rate of return in the Euro Area would

[2]See Hsiao (2003), chapter 4.

[3]This assumption will be made throughout the paper.

Table 3: GMM estimates of US foreign direct investment in the UK. Sample period:1982-1998.

	[1]		[2]	
Variable	Coefficient	t-value	Coefficient	t-value
$FDI_{uk,t-2}$	-0.020739^{*}	-1.76		
$FDI_{eu,t-2}$	0.0577748^{**}	4.85		
$RR_{uk,t-2}$	-0.00036387^{**}	-4.40		
$RR_{eu,t-2}$	-0.000305715^{**}	-3.43		
$USLR_{t-2}$	0.0157985	1.51	-0.327862^{**}	-2.19
RRX_{t-2}	0.0293338^{**}	2.54	0.0443337^{*}	1.77
$\sigma_{uk,t-2}$	0.143071^{**}	4.02	-0.367782^{**}	-2.17
$\sigma_{eu,t-2}$	-0.0103230^{**}	-4.11	0.696059^{**}	2.16
ρ_{t-2}	0.00636854^{**}	3.91	0.213677^{**}	2.11
$RFDI_{t-2}$			-0.378010^{**}	-2.05
RRR_{t-2}			0.349345^{**}	2.26
$\Delta FDI_{uk,t-1}$	-0.0983330^{**}	-2.86		
$\Delta FDI_{eu,t}$	0.0617439^{**}	3.76		
$\Delta FDI_{eu,t-1}$	-0.0440503^{**}	-4.54		
$\Delta RR_{uk,t}$	-0.000149372	-1.41	0.00194151^{**}	2.15
$\Delta RR_{uk,t-1}$	0.0004093^{**}	3.03	-0.000454746^{**}	-2.02
$\Delta RR_{uk,t-2}$			$6.81163e-005^{**}$	1.71
$\Delta RR_{eu,t}$	0.000197497^{**}	4.32		
$\Delta RR_{eu,t-1}$	$7.60663e-005^{**}$	2.20		
ΔRRX_{t}	-0.0077929^{*}	-1.94		
ΔRRX_{t-1}	-0.0653882^{**}	-2.64		
$\Delta\sigma_{uk}$	0.0253299^{**}	3.82	-0.0788412^{**}	-1.97
$\Delta\sigma_{uk,t-1}$	0.0429749^{**}	2.71	-0.203332^{**}	-2.23
$\Delta\sigma_{eu,t}$	0.0199979^{*}	1.74		
$\Delta\sigma_{eu,t-1}$	-0.00698858^{*}	-1.74		
$\Delta\rho_{t}$	-0.00877742	-1.56		
$\Delta\rho_{t-1}$	0.00210227	0.269		

Model 1:σ=0.7242401,σ^2=0.5245238 RSS=7.8678566788,TSS=3.207809963,no. of observations=58, no. of parameters=43. Transformation used:orthogonal deviations. Level instruments:Dummies,lrfdiuk(-2),rcorr(-2),rvareu(-2),rvaruk(-2),rrruk(-2) rrreu(-2),ruslr(-2),lrfdieu(-2),dlfdiuk(-1),dlfdieu,drcorr,drvaruk,drvaruk(-1), drreu,drruk(-1),drreu(-1),drcorr(-1),drruk,dlfdieu(-1),lrukeurx(-2),dlrukeurx,dlrukeurx(-1) drvareu,drvareu(-1),druslr,druslr(-1),Gmm(dlfdiuk,3,99). Wald (joint):$\chi^2(24)$=1180. [0.000], Wald (dummy):$\chi^2(19)$=1180. [0.000], Wald (time):$\chi^2(13)$=1180. [0.000], Sargan test:$\chi^2(104)$=7.992e-016 [1.000], AR(1) test:N(0,1)=-1.837 [0.066], AR(2) test:N(0,1)= 1.815 [0.069]

Model 2:σ=1.696882,σ^2=2.87941, RSS=80.623477618,TSS=3.3268586754, no. of observations=59,no. of parameters=31,Transformation used:none, Level instruments:Dummies,lfdiukeu(-2),rrukeu(-2),lrukeurx(-2),ruslr(-2), rcorr(-2),rvareu(-2),rvaruk(-2),drvaruk,drvaruk(-1),drruk, drruk(-1),drruk(-2),Gmm(dfdiukeu,3,99).Wald (joint):$\chi^2(12)$=13.22 [0.353] Wald (dummy):$\chi^2(19)$=13.22 [0.827],Wald (time):$\chi^2(13)$=13.22 [0.431], Sargan test:$\chi^2(104)$=-4.463e-014 [1.000],AR(1) test:N(0,1)=1.842 [0.066], AR(2) test:N(0,1)=1.483 [0.138].

** and * denote a diagnostic test significant at 5% and 10%, respectively. For Wald, Sargan, and AR(.) tests, the p-value is given.

relocate FDI from the UK to the Euro Zone. Finally, we note that the exchange rate correlation has a positive and significant sign. This positive coefficient indicates that US FDI in the UK increases as exchange rates become more correlated. A perfect positive correlation diminishes risk diversification opportunities, as both rates move in the same direction. Investment location would then be determined by other factors, e.g. higher rate of return or more flexible labour market. This result is quite robust to changes in model specification, since correlation has a positive coefficient in column [1] and column [2].

A general to specific nested procedure produced the results presented in Table 3, column [2]. The opposite signs of $FDI_{uk,t-2}$ and $FDI_{eu,t-2}$, the negative sign of the Euro Area rate of return and the poor significance of some dynamic terms in the general model, lead us to estimate US FDI in the UK as a ratio of US FDI in the Euro Area. This specification not only generates the best results, but also emphasizes the role of location choice of US firms in Europe. We replaced the country specific rates of return $RR_{uk,k,t-2}$ and $RR_{eu,k,t-2}$ by the ratio of the former over the latter, $RRR_{k,t-2}$. Similarly, we replaced the dependent variable $\Delta FDI_{uk,k,t-2}$ by the log of the ratio of real US FDI in industry k ($RFDI_{k,t}$)in the UK industry k to real FDI in the Euro Area in industry k ($RFDI_{k}, t$).

All coefficients are significant and correctly signed, except the coefficient of RRX_{t-2}, which is positive but not significant at the 5 per cent level. We expected the sterling euro exchange rate to have a negative impact on FDI or possibly no impact at all. As mentioned above, domestic sales rather than exports to the European Union are the main source of income of UK affiliates. Exports represented a larger share of total sales in some industries over the sample period. UK affiliates in Machinery and Chemicals, for instance, exported on average 40 and 28 per cent of their total sales, respectively. However, in the remaining industries included in our sample, the average share of exports was less than the 23 per cent average share of the manufacturing industry as a whole. Table 3 lends support to our theoretical assumptions about US firms' attitude to risk. U.S. firms investing in the UK tend to be risk-averse and decrease their investment when the relative volatility of the dollar-pound exchange rate increases. On the contrary, rises in the volatility of the euro dollar exchange rate tend to divert US investment from the Euro Area to the UK. The coefficient of $\sigma_{uk,t-2}$=-0.37 and the coefficient of $\sigma_{eu,t-2}$=0.696.

Finally, Table 4 corroborates our finding that increases in exchange rate correlation lead to a relocation of investment from the Euro Area to the UK. Table 4 presents the results of the estimation of equation (38) for US direct investment in the Euro Area. Two sets of results are shown. In column [1], the sterling euro exchange rate is included in the long-run relationship, following (38). However, it was not found significant, and equation (38) was subsequently re-estimated excluding RRX_{t-2} . Column [2] shows the results of this alternative estimation. In both cases the coefficient of the exchange rate correlation is negative. It is significant in column [2] but not in column [1]. Removing the sterling euro exchange rate from the long-run relationship improves the significance of the correlation and of rate of return on FDI in the Euro Area. The euro dollar exchange rate volatility and the U.S. interest rate have negative signs, as anticipated, and are significant at 5 per

Table 4: GMM estimates of US foreign direct investment in the Euro Area. Sample period:1982-1998.

	[1]		[2]	
Variable	Coefficient	t-value	Coefficient	t-value
$FDI_{eu,t-2}$	-0.346331^{**}	-3.26	-0.340736^{**}	-3.24
$RR_{eu,t-2}$	$5.96 * 10^{-5}$	1.28	$7.46334 * 10^{-5*}$	1.81
RRX_{t-2}	0.00784355	0.69		
$USLR_{t-2}$	-0.122796^{**}	-3.05	-0.123328^{**}	-3.04
ρ_{t-2}	-0.0338988	-1.52	-0.0438151^{*}	-1.80
$\sigma_{eu,t-2}$	-0.0112264^{**}	-6.39	-0.0120693^{**}	-4.29
$\Delta FDI_{eu,t-1}$	0.0232151	0.79	0.0145616	0.357
$\Delta CPI_{eu,t}$	0.00491248	1.58	0.00501553^{*}	1.76
$\Delta USLR_t$	-0.0884616^{**}	-2.54	-0.0816780^{**}	-2.42
$\Delta\rho_t$	-0.0461836^{**}	-2.48	-0.0464129^{**}	-2.59

[1] σ=0.5113763, σ^2=0.2615057, RSS=8.3681814578, TSS=2.218376681,no. of observations=60, no. of parameters=28,Transformation used:orthogonal deviations. Level instruments:Dummies, dlfdieu(-1),lrfdieu(-2),ruslr(-2), rcorr(-2),rvareu(-2),rrreu(-2),dlcpieu,lcpieu,druslr,drcorr, Gmm(dlfdieu,3,99).Wald (joint):χ^2(9)=118.1 [0.000] , Wald (dummy):χ^2(19)=118.1 [0.000], Wald (time): χ^2(13)=118.1 [0.000] ,Sargan test:χ^2(105)=7.534e-015 [1.000], AR(1) test:N(0,1)=-1.614 [0.107],AR(2) test:N(0,1)=1.345 [0.179]. **[2]**:σ=0.5366653,σ^2=0.2880097,RSS=8.9283005972, TSS=2.218376681,no. of observations=60,no. of parameters=29, Transformation used:orthogonal deviations,Level instruments:Dummies, dlfdieu(-1),lrfdieu(-2),ruslr(-2),rcorr(-2),rvareu(-2),rrreu(-2), dlcpieu,lcpieu,druslr,drcorr,lrukeurx(-2),Gmm(dlfdieu,3,99), Wald (joint):χ^2(10)=199.4 [0.000], Wald (dummy):χ^2(19)=199.4 [0.000], Wald (time):χ^2(13)=199.4 [0.000] Sargan test:χ^2(105)=1.176e-014 [1.000], AR(1) test:N(0,1)=-1.578 [0.115], AR(2) test:N(0,1)=1.239 [0.215].
** and * denote a diagnostic test significant at 5% and 10%, respectively. For Wald, Sargan, and AR(.) tests, the p-value is given.

cent.

The econometric analysis of US FDI in the UK and the Euro Area presented above allows us to conclude that US firms investing in Europe tend to be risk- averse, and that their preferred location tend to be the UK. As exchange rate correlation converges towards 1, exchange rate risk diversification becomes a weaker determinant of location whilst other factors like rate of return become more relevant. There is ample evidence in the literature that market size and labour market flexibility, factor productivity, fiscal competitiveness, among others, are strong determinants in the choice of FDI location.

Market power

Our sample consists of two groups comprising low Herfindahl industries and high Herfindahl industries, respectively. In the UK the latter is composed by Food, Chemicals, Electrical Equipment, and Transportation Equipment. Primary Metals, Machinery and Equipment, and Other Manufacturing Industries form the group of low Herfindahl industries. In the Euro Area, Chemicals, Electrical Equipment and Transportation Equipment are high- Herfindahl industries, whilst Food, Primary Metals, Machinery and Equipment, and Other Manufacturing Industries can be considered low-Herfindahl industries.It should be noted that the Herfindahl Index of the Euro Area is an aggregate measure of concentration over the European Union, and thus covers more countries than the Euro Area. In particular, it includes the United Kingdom. For this reason, we chose to classify the industries according to the European Herfindahl Index.

The criterium used for splitting the sample is the higher benchmark value of the Herfindahl index published in the US Department of Justice Merger Guidelines. Two critical thresholds for measuring industrial concentration are considered in the guideline, H=0.10 and H=0.18. All the industries in our sample have Herfindahl indices greater than 0.10. We then split our sample into groups of industries with Herfindahl indices lower and greater than 0.18, respectively.

To analyse of the impact of market power on risk-aversion, we test the equality of the coefficients of the variances for the two groups of industries considered above. We split the data on conditional variances in accordance to the level of the Herfindahl index. Equation (38) then becomes,

$$\begin{aligned}\Delta RFDI_{k,t} = \phi RFDI_{k,t-2} + a_1 RRR_{k,t-2} + a_2 USLR_{t-2} + a_3 \sigma^2_{uk,t-2,H} + \\ a_4 \sigma^2_{uk,t-2,L} + a_5 \sigma^2_{eu,t-2} + a_6 \rho_{uk,eu,t-2} + a_7 RRRX_{t-2} + \\ \bigtriangledown \left(RFDI_{k,t}, RRR_{k,t}, \sigma^2_{uk,t,H}, \sigma^2_{uk,t,L}, \sigma^2_{eu,t}, \rho_{uk,eu,t}\right) + \gamma_{i,k} + u_{k,t}\end{aligned} \tag{39}$$

where $\sigma_{uk,t-2,H} = \sigma^2_{uk,t-2} * \delta_H$ and $\sigma^2_{uk,t-2,L} = \sigma^2_{uk,t-2} * (1 - \delta_H)$. $\delta_H = 1,\ if\ H > 0.18$ and $\delta_H = 0,\ otherwise$. $\sigma_{uk,t-2,H}$ can be interpreted as the variance associated with high Herfindahl industries in the UK and $\sigma_{uk,t-2,L}$ the variance associated with low Herfindahl industries in the UK. We then test the hypothesis that the two variances are equal. Results are reported in Table 5. All coefficients are significant at the 5 per cent and 6 per cent levels. The coefficients of the split variances are negative confirming our earlier results that the volatility of the sterling dollar exchange rate has a negative impact on investment in all industries in the UK. The real sterling euro exchange rate has a positive coefficient in column [1]. Excluding this variable from the long run relationship does not affect the significance or the sign of the remaining variables.

We expect the coefficient of $\sigma_{uk,t-2,H}$ and $\sigma_{uk,t-2,L}$ to be statistically different. There is empirical evidence that US firms with market power tend to absorb exchange rate changes into their prices and their mark-up. Campa and Goldberg (1995) show that high mark-up firms are less responsive to changes in exchange rate volatility than low mark-up firms. Domestic investment by high mark-up US firms thus tend to be invariant to exchange

Table 5: GMM estimates of US foreign direct investment in the UK Split variances.

	[1]		[2]	
Variable	Coefficient	t-value	Coefficient	t-value
$RFDI_{t-2}$	-0.260680^{*}	-2.00	-0.259772	-1.99
ρ_{t-2}	0.248692^{**}	2.17	0.249420	2.17
$USLR_{t-2}$	-0.339796^{**}	-2.20	-0.344609	-2.19
RRR_{t-2}	0.321555^{**}	2.46	0.325835	2.46
RRX_{t-2}	0.108599^{**}	2.15		
$\sigma_{uk,t-2}$ High	-0.246926^{**}	-2.20	-0.250678	-2.20
$\sigma_{uk,t-2}$ Low	-0.222771^{**}	-2.26	-0.226249	-2.26
$\sigma_{eu,t-2}$	0.539943^{**}	2.19	0.537189	2.19
$\Delta\sigma_{uk,t-1}$High	-0.0878435^{*}	-1.98	-0.0899327	-1.98
$\Delta\sigma_{uk,t-1}$Low	-0.086738^{**}	-2.60	-0.0882757	-2.59
$\Delta RR_{uk,t}$	0.00094947^{**}	2.19	0.000958483	2.16
$\Delta RR_{uk,t-1}$	0.000419807^{*}	1.98	0.000421341	1.98
$\Delta RR_{uk,t-2}$	-0.000340198^{*}	-1.99	-0.000341463	-1.99
$\chi^2(1) = 2.70842^{\dagger}$			$\chi^2(1) = 2.73004^{\dagger}$	

σ=1.555853,σ^2=2.420679,RSS=65.35833463, TSS=3.3268586754,no. of observations=59,no. of parameters=32,Transformation used: none.Level instruments:Dummies,drruk,drruk(-1),drruk(-2),rcorr(-2),ruslr(-2),rrukeu(-2),lrukeurx(-2),varuk1(-2),varuk2(-2),rvareu(-2),lfdiukeu(-2),dvaruk1(-1), dvaruk2(-1),Gmm(dfdiukeu,3,99).Wald (joint):χ^2(13)=18.47 [0.141], Wald (dummy):χ^2(19)=18.47 [0.491],Wald (time):χ^2(13)=18.47 [0.141], Sargan test:χ^2(104)=-3.363e-014 [1.000],AR(1) test:N(0,1)=2.280 [0.023], AR(2) test:N(0,1)=1.762 [0.078]

** and * denote a diagnostic test significant at 5% and 6%, respectively. † denotes a diagnostic test significant at 10%. For Wald, Sargan, and AR(.) tests, the p-value is given.

rate volatility. The estimations reported in Table 5 suggest that this result may not be easily extended to foreign investment by US firms. We cannot firmly conclude that FDI into highly concentrated industries in the UK and FDI in less concentrated industries are distinctly affected by exchange risk. The test of equality of the coefficients of the two variances is accepted at the 5 per cent level, but may be rejected at the 10 percent level. Moreover, we note that the coefficient of the variance associated with high Herfindahl industries is bigger than that associated with low Herfindahl industries. This suggests -unexpectedly- that the former are more sensitive to exchange rate risk than the latter.However, tht risks inherent to investment in foreign countries may be sufficiently strong to offset firms' market power.

4 Conclusion

In this paper we have sought to isolate the impact of exchange rate risk on US FDI in Europe, emphasizing the interaction between exchange rate uncertainty, exchange rate correlation and market power. We constructed a model based on the hypothesis that risk-averse firms would attempt to reduce the impact of uncertainty on their investment portfolio by exploiting correlations bewteen exchange rates in alternative locations. We also showed that market power reduces the negative impact of uncertainty on investment.

We test our theoretical model on US foreign direct investment in Europe, using a panel of seven two-digit industries. We find that exchange rate uncertainty in the Euro Area and in the UK has a strong negative effect on FDI. There is strong evidence that the correlation between the sterling dollar exchange rate and the euro dollar exchange rate influences location decisions of US firms in Europe. In particular, we found evidence that, as the exchange rate correlation move towards 1, US firms tend to divert their investment from the Euro Area to the UK.

Finally, our results show that the degree of industrial concentration has little influence on the impact of exchange rate volatility on US FDI in Europe. Using the degree of industrial concentration as a proxy for monopoly power, we found that FDI in industries with low monopoly power is not diversely affected by exchange rate volatility than FDI in highly concentrated industries.

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Data Appendix

The data on US outward direct investment and data on affiliates of US firms abroad were obtained from the Survey of Current Business of the Bureau of Economic Analysis, 1982-2001. These data include FDI at historical cost, the net income reported by affiliates, total, local sales, sales to the US and sales to "other" countries. The sterling dollar exchange rate and the US Consumer price Index were obtained from the OECD Main Economic Indicators and the euro dollar exchange rate from the IFS (1999 onwards). Prior to 1999, the euro dollar exchange rate was linked to ECU. Data used for the construction of the Herfindahl Index were obtained from Eurostat NewCronos database. The UK consumer price index is given by the ONS, Economic Trends.