Does exchange rate volatility really depress Foreign Direct Investment?

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Abstract

The effect that exchange rate uncertainty might have on outward Foreign Direct Investment (FDI) flows has become a highly debated topic. However, most of the existing empirical studies are based on a small set of countries and therefore highlight contradictory results. This paper then considers a broad bilateral panel data set of 28 OECD countries over the period 1982-2002. The relationship is on average negative and significant when standard OLS Fixed Effects and GLS Random Effects estimations are considered. However, we theoretically and empirically argue that a system GMM of Dynamic Panel estimation is necessary to control for the endogeneity issue and we provide evidence of a bias in both the estimates and the standard errors. The correct average relationship thus becomes smaller and statistically insignificant. We also show that the negative effect appears to be significantly decreasing over the 1990-2002 period, even becoming positive since the mid-1990s. Therefore, policies aiming at attracting Foreign Direct Investment through a stabilization of relative exchange rates appear to be much less efficient than expected.

JEL Keywords & Codes:
International Investment (F21), Multinational Firms (F23), Foreign Exchange (F31)

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1 Introduction

For policy makers, the last two decades engendered a shift in perception on issues related to foreign
direct investment (FDI). Once considered undesirable, suspicious, and dangerous to the invested
country, FDI became viewed as beneficial and conducive to economic growth. Nowadays, attracting
foreign investment is a commonly stated goal of regional and national governments. Among many
other factors, the exchange rate regime in place plays an important role in influencing the attrac-
tiveness of a region to FDI. Indeed, the stability of the currency is frequently seen as one of the
necessary conditions for increasing investment.

At first glance, it seems sound to presume that the more volatile the currency is expected to be
for a country, the less likely are foreign firms to invest in this economy. Indeed, through foreign direct
investment, multinationals have operations that generate cash flows in foreign currencies and hence
fluctuations in the exchange rate could have important effects on the value of the firm. Mismatches
between income and expenses due to movements in relative value of currencies can trigger significant
losses and even bankruptcy. This uncertainty would thus naturally depress foreign direct investment
spending in risk-averse firms.

Moreover, a negative relationship could also be expected if one considers the view offered by
option pricing. Not only would uncertainty in the exchange rate create an incentive for firms to
avoid entering a foreign market today because it would be optimal to pursue a “wait and see”
strategy, but the more volatile the exchange rate, the greater this incentive becomes. As known in
option pricing, the ratio of the market price, at which a call option is exercised, to the strike price
is higher the greater is market volatility. Because FDI generally involves sunk costs in the foreign
country, the best response of a multinational would be to wait for a more favourable exchange rate
before investing abroad. As a consequence, when investment spending is realized by the firm, the
option to invest may no longer be available. Therefore, irreversibility of investment expenditures
and the option of waiting for new information render the investment decisions of the firms sensitive
to real exchange rate uncertainty. Campa (1993), for instance, builds on such foundations - laid by
Dixit and Pindyck (1994) - and asserts that unpredictable fluctuations in the exchange rate introduce
added uncertainty into both the production costs and future revenues of overseas operations, thus
deterring entry by foreign investors contemplating investment in the U.S.

However, the conclusions drawn from the theoretical literature on the effects of exchange rate
volatility on FDI are not so obvious and the empirical evidence rather scarce. In general, existing
theoretical papers can be divided into two approaches. The first is offered by a strand of scholars
who provide an argument based on the flexibility of long-run production. Among them, Aizenman
(1992), Darby et al. (1999), and Sung and Lapan (2000) formulate models in which foreign and
domestic capacity decisions by multinationals are made ex ante, while employment decisions are
made ex post, following the realization of real or nominal stochastic shocks. While Aizenman’s
(1992) model suggests a negative relationship between endogeneous exchange rate volatility and

\[Since the key aspect here is the sunk cost, a very convenient feature is that the results hold even for risk-neutral firms.\]
FDI, the other two papers expand upon the original Dixit and Pyndick (1994) framework and propose conditions under which volatility can boost FDI.

A second approach has been put forth by Cushman (1985, 1988), Goldberg and Kolstad (1995), and Bénassy-Quéré et al. (2001). These authors consider risk-aversion in the short-run, with no possibility of adjusting the productive factors after the shock is realized, where the risk in question is related to the time lag between investment expenditure and profits received in foreign currency. In this light, Cushman (1985, 1988) shows that exchange rate volatility may have positive effects on FDI, through lower foreign capital costs, by using bilateral FDI flows from the United States to the United Kingdom, France, Germany, Canada and Japan for 1963-1978. In another study, Goldberg and Kolstad (1995) similarly argue that exchange rate volatility may stimulate home investors to seek opportunities abroad. Their study assumes that under risk aversion, the nature of the relationship depends crucially on the covariance structure between the exchange rate and foreign demand shocks. If both shocks are negatively correlated, a larger variability of exchange rate would magnify the share of capacity located abroad, although the overall capacity would decline. Using quarterly data of bilateral FDI flows from the United States to the U.K., Canada and Japan for 1978-1991, they performed a time series analysis on individual country data and confirmed a positive relationship. In contrast, Bénassy-Quéré (2001) extends Cushman’s theoretical work, and investigates the role played by the covariance between exchange rates of currencies used in two alternative locations on FDI from industrialized countries into developing economies. The risk-averse multinational contemplates relocation to two different countries in order to re-export from there to the home country. The authors find by using a panel dataset of 42 emerging and 17 OECD countries for 1984-1996 that exchange rate volatility in developing economies has a negative impact on OECD outward FDI to these countries. Similar empirical evidence is offered by Brzozowski (2003) with a set of 19 emerging market and 13 transition countries during the 1990s and by Chakrabarti and Scholnick (2002) in which they consider FDI flows from the U.S. to 20 OECD countries.

Regarding aggregate investment in general, there also exists a few interesting papers analyzing the influence of the exchange rate volatility\(^2\). For instance, Byrne and Davis (2002) assessed a range of uncertainty measures in the G7 and found that only those related to real exchange rate uncertainty were significant. Using GARCH measures of uncertainty, Serven (2003) also concluded that this effect was important on private investment using evidence from 61 developing countries. In a more recent paper, Byrne and Davis (2005) investigate the impact of permanent vs. transitory components of effective exchange rate volatility on investment in the G7, using an asymmetric EGARCH approach. Their results provide evidence that it is the transitory and not the permanent component of volatility which adversely affects investment. In order to verify the validity of this claim for FDI flows, we consider here a very standardized long-term historical volatility to eliminate the transitory component.

Then, because of the fundamental heterogeneity of these empirical analyses and theoretical

\(^2\)They do not consider any theoretical framework to explain the sign of the estimate and there is no particular reason to believe that aggregate investment flows should behave like FDI flows. They remain however interesting since FDI flows accounted for a large proportion of total investment flows in the 1990s.
predictions, there is no definitive study to date that settles the theoretical and practical disputes of the effect of volatility on FDI. The main drawback of these empirical works is the small number of countries (and years) considered to be able to provide clear-cut results. Although Bénassy-Quéré et al. (2001) use a broad set of countries, they focus on North-South bilateral investments which should be considered in a completely different framework from the explanation of North-North FDI.

In this work, we are considering a panel analysis covering 28 OECD countries (or 756 flows per year) over the 1982-2002 period. Therefore, because our data set is much richer than other econometric studies that we are aware of, we should be able to provide more efficient information about the relationship between exchange rate risk and outward FDI flows in industrialized countries. Using both GLS Random Effects and OLS Fixed Effects estimations, the results turn out to unambiguously present an average effect being negative and highly statistically significant. However, we argue that both these estimates and standard errors are potentially subject to an endogeneity bias. Indeed, common macroeconomic factors are likely to influence, at the same time, the FDI flows, the exchange rate volatility and the GDP of the home and the recipient countries. Therefore, when controlling for the endogeneity of the explanatory variables with a system GMM Dynamic Panel Data estimation with robust standard errors, the exchange rate uncertainty effect become smaller and statistically insignificant. The conclusions remain the same when varying the estimation procedure, which insures the robustness of our finding. Therefore, we are able to provide evidence of the existence of a severe bias if an appropriate econometric approach is not taken into consideration. In addition, we also provide a simple theoretical model which is able to capture this potential bias and offers an interesting interpretation.

Surprisingly, none of the existing studies offers an analysis of the effects over time. The negative relationship may be expected to become weaker over time since firms now have access to financial instruments to hedge their currency exposure. For the past 20 years, the purchase and trading of options and futures have greatly increased and even become common practice. In this light, multinationals should gradually become unaffected by exchange rate fluctuations. Nevertheless, to be able to fully hedge a foreign currency exposure, a firm must precisely know the amount to be hedged, such as profits to repatriate to the home country. This is difficult since profits are highly volatile and no financial derivatives could be used to guarantee a steady income. Moreover, because hedging derivatives are a positive function of the underlying asset’s volatility, the greater the variability of the exchange rate, the more costly the hedging strategy will be. Hence, high fluctuations of profits coupled with the potentially large (although decreasing) costs of financial derivatives could lead multinationals, in some cases, not to consider hedging as the best response to the currency risk. The predicted effect is thus not crystal clear and we believe that only an analysis of the relationship over time could provide the full picture. Therefore, the evolution of the effect is accounted for in this paper. Using a standard panel Random Effects estimation, not only does it appear that the influence of exchange rate uncertainty on FDI flows is non-linearly decreasing over time, but the relationship even becomes insignificant in recent years. However, this may be misleading because of the endogeneity bias that needs to be accounted for. Using the GMM approach, although the effect seems to also be decreasing over time, there is a sign change in
the mid 1990s, thus suggesting a rather positive influence on FDI flows in industrialized countries. This decreasing effect is fully supported by our theoretical model and constitutes a major finding regarding the potential policy implications that such a result might imply.

As mentioned above, we also provide a simple intuitive model which contributes in the understanding of the obtained negative relationship between FDI flows and exchange rate volatility. The underlying foundation of the framework is the trade-off that a risk-averse profit maximizing multinational faces between exporting capital and exporting goods when the firm decides to expand its market. More precisely, we assume that investing abroad allows the firm to benefit from lower costs per output on average. However, these costs become stochastic due to the randomness of the exchange rate and the magnitude of such uncertainty will influence the choice between investing and exporting abroad. We derive the model with both an exogeneous and an endogeneous exchange rate to illustrate the potential bias emanating from the presence of shocks affecting both foreign investment and the exchange rate.

The main goal of this study is thus to investigate the correct effect of foreign currency fluctuations on aggregated outward FDI. Empirical studies find contradicting results and helping to clarify this debate is the motivation for this work. We also believe that there exists an endogeneity bias that needs to be accounted for and provide some empirical evidence. The rest of the paper is organized as follows. Section 2 outlines an intuitive model underlying the relationship between exchange rate uncertainty and FDI. Section 3 describes our estimation strategy while Sections 4 & 5 are devoted to data analysis, econometric results and concerns. We finally state our conclusions in Section 6.

2 A Theoretical Framework

We derive here a simple model whose unique goal is to understand how exchange rate volatility can affect the amount of FDI spending between two countries. Since we are interested in FDI flows among industrialized countries, we rule out the North-South hypothesis that multinationals benefit from outsourcing abroad the goods sold later on in the home market. In our framework, firms exogenously decide to start selling their goods abroad and will thus try to capture part of a foreign market. We do not consider the choice of an extension of the firm’s market but rather investigate, given this conditional decision, what the optimal choice of the firm would be between producing at home and then exporting the goods, or investing in a plant abroad to produce the goods locally. In both cases, the firm might be subject to foreign shocks on the demand side. A way to circumvent the problem of proxying these shocks is to consider what we call "net profit": it represents the difference between profits coming from producing abroad and profits from producing at home, thus canceling out the unobservable effects. In our framework, a representative risk-averse multinational thus maximizes its net profit and chooses the optimal amount of FDI spending subject to variables such as the exchange rate volatility.
2.1 The Model

Imagine a representative firm maximizing its future net profit and living for an infinite number of periods. The firm chooses an optimal level of FDI that will be invested in country \( j \) at time \( s \) (today), considering the pay-off of producing domestically in country \( i \). The sequence of the production is as follows: the firm chooses to invest in a plant today only if it decides to produce the good abroad (not at home since the plant already exists) and, in either situation, produces and sells the good in country \( j \)'s market during the next periods. Besides the investment spending in the plant, all transactions are observed in future dates and are thus subject to a change in the exchange rate if the transactions are in country \( j \)'s currency. The firm maximizes the discounted value of an infinite stream of net profits starting at \( t = s \), the time of investment spending:

\[
Max_{FDI} E(\pi^{net}) \text{ with } \pi^{net} = \max [\pi_{FDI} - \pi_{Export}, 0]
\]  

(1)

where \( \pi_{FDI} \) is the profit obtained by producing the good in the country \( j \) and \( \pi_{Export} \) corresponds to the situation in which the firm produces at home and finally export the good to country \( j \). Therefore, the firm invests in country \( j \) if and only if this opportunity makes it better off in terms of discounted profits:

\[
FDI \geq 0 \iff \pi^{net} = \pi_{FDI} - \pi_{Export} \geq 0
\]  

(2)

We define the discounted profits\(^3\) \( \pi_{FDI} \) and \( \pi_{Export} \) as follows:

\[
\pi_{Export} = \sum_{t=s}^{\infty} \frac{1}{(1+r)^{t-s}} \left[ \frac{e_t}{e_s} R_t - c_{it} Q_{jt} \right]
\]  

(3)

\[
\pi_{FDI} = \sum_{t=s}^{\infty} \frac{1}{(1+r)^{t-s}} \left[ \frac{e_t}{e_s} R_t - \frac{e_t}{e_s} c_{jt} Q_{jt} \right] - FDI_s
\]  

(4)

where \( r \) is the interest rate, \( R_t \) is total revenue of selling the good on country \( j \)'s market at time \( t \) using today’s exchange rate, \( c_{it} \) and \( c_{jt} \) the costs of production per unit of output in country \( i \) and \( j \) in country \( i \)'s currency using today’s exchange rate, and \( Q_{jt} \) the optimal quantity to produce and to sell in country \( j \), independent on the location of production. Finally, \( e_t \) is time \( t \) value of country \( i \)'s currency relative to country \( j \)'s currency, \( \frac{e_t}{e_s} \) corresponds to the relative exchange rate change between today and time \( t \), and \( FDI \) is the amount of FDI to invest in country \( j \). Note that the costs of production depend on the change of the exchange rate only in the case of producing the good abroad. The net profit at time \( t \) can be written as

\(^3\)Note that while maximizing shareholder value, which equals the present value of future profits, the firm only cares about the profits denominated in country \( i \)'s currency.
\[
\pi^{\text{net}} = \pi_{\text{FDI}} - \pi_{\text{Export}} = \sum_{t=0}^{\infty} \frac{1}{(1+r)^{t-s}} \left[ Q_{jt}(c_{it} - \frac{e_t}{e_s} c_{jt}) - \text{FDI}_t \right]
\] (5)

This equation highlights the nondependency of the net profit \(\pi^{\text{net}}\) on the revenues of the firm \(R_t\). Therefore, the decision of investing abroad of the profit-maximizing firm is not subject to any shocks on the demand side of the market.

It is useful now to denote a few properties of the variables entering the above equation. First of all, the optimal quantity \(Q_{jt}\) to produce and to sell in country \(j\) obviously depends on the overall country \(j\)'s demand for that good and thus on the size of country \(j\)'s market. Thus,

\[
Q_{jt} = Y_{ij}^\mu, \quad \mu > 0
\] (6)

where \(Y_{ij}\) is the size of country \(j\), in terms of GDP, proxying the size of the demand market.

Since FDI between industrialized countries is mainly aimed at serving the foreign market through investing abroad, as opposed to outsourcing, a larger market should more likely increase sales\(^4\).

Regarding the costs per unit of output of production \(c_i\) and \(c_j\), we can assume that

\[
c_{it} = c_i \quad \text{for all } t
\] (7)

\[
c_{jt} = c_i Z_t \Psi \text{FDI}_t^{-\beta} \leq c_t c_i, \quad \Psi, \beta > 0
\] (8)

In this set up, the cost per output is considered to be constant, should the firm produce at home. On the other hand, the costs of producing a good abroad is the product of a linear function of the costs \(c_i\), a decreasing convex function of the amount of FDI spending and a function \(Z_t\) of other constant variables that we will describe later on.

As we can see so far, there is a trade-off between exporting capital and exporting goods: investing abroad allows the firm to benefit from lower costs per output \(c_{jt} < c_i\). However, costs \(c_{jt}\) are subject to an exchange rate change while converted in domestic currency and, in addition to that, an amount \(\text{FDI}\) has to be spent today. More precisely, the larger is the FDI spending from the firm, the less costly the production per output will be in the future and then, the less the profits depend on the relative exchange rate movements, although the less will also be the initial profit due to the investment.

We can assume, as it is standard in the literature, a lognormal distribution of the exchange rate such that the best prediction of the exchange rate at time \(t\) is its value as of today:

\[
\ln \left( \frac{e_t}{e_s} \right) \sim N(0, \sigma_e^2)
\] (9)

From Laplace transform, we can deduce that the expected change of the exchange rate is given by

\(^4\)Note that no restriction is imposed here on the convexity or concavity of the relationship.
where $A$ is a function of the coefficient of constant risk-aversion of the representative firm. As an interpretation of the result, the risk-averse firm is now indifferent between receiving an amount $k$ in the home currency subject to the volatility of the relative exchange $\sigma_{et}^2$, and receiving the amount $k \exp(-\frac{1}{2} AE_s \left[ \sigma_{et}^2 \right])$, obviously smaller than $k$ but risk-free. A large volatility of the profit due to the uncertainty of tomorrow’s value of the exchange rate will thus naturally lower the incentive of investing abroad.

Let’s combine the different equations along the certainty equivalent level of net profits to obtain a function of the expected net profit subject to the filtration $F_s$:

$$E \left[ \pi^{\text{net}} \mid F_s \right] = \sum_{t=s}^{\infty} \frac{1}{(1 + r)^{t-s}} E \left[ \pi \mid F_s \right] - FDI_s \quad \text{with (11)}$$

$$E \left[ \pi \mid F_s \right] = Y_{it}^\mu (c_i - \exp(-\frac{1}{2} AE_s \left[ \sigma_{et}^2 \right]) \Psi c_i Z_s FDI_s^{1-\beta}) \quad \text{(12)}$$

Since we are mainly concerned about the sign of the effect of the exchange rate risk on FDI flows, we use here the assumption that all other variables are assumed to be deterministic with zero drift and to have zero covariance between each other. In this setting, the firm wants to determine the optimum level of FDI at time $s$ that maximizes $E(\pi^{\text{net}} \mid F_s)$ and sets the First Order Condition as

$$\frac{1}{r} \beta Y_{sj}^\mu Z_s (FDI_s)^{-\beta-1} \exp(-\frac{1}{2} AE_s (\sigma_{et}^2)) - 1 = 0 \quad \text{(13)}$$

We can then obtain the optimal amount of $FDI_s$ with respect to the exchange rate volatility and other variables:

$$FDI_s = \left[ \frac{1}{r} \beta Y_{sj}^\mu Z_s \exp(-\frac{1}{2} AE_s (\sigma_{et}^2)) \right]^{\frac{1}{1+\beta}} \quad \text{(14)}$$

where $Z_{sij}$ is a function of constant variables usually considered in the literature to influence the optimal amount $FDI_s$ through an effect on the costs per good that is produced and sold abroad. We define

$$Z_s = \exp(\phi D + \Psi B + \varphi L + \sum \eta_i X_s) \quad \text{(15)}$$

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5We consider, here and in the empirical part, that the firm is taking today’s current values (that is to say, $t = s$) of all the variable as the best prediction of their future values. It is thus assumed that the volatility of exchange rate follows a random walk such that $\sigma_{et+1}^2 = \sigma_{et}^2 + \nu_t$ with $\nu_t \sim N(0, \zeta_t^2)$ a white noise process independent of $\sigma_{et}^2$. 8
where $D$ is the distance between country $i$ and country $j$. It has an ambiguous effect on the costs per output in any case since distance increases transportation costs both for the exported good and for intermediate goods, conditional on the decision of the firm to sell abroad. However, the probability to sell abroad is inversely proportional to the distance between countries; $B$ is a dummy variable that is equal to 1 if the sending and the host countries share a common border, 0 otherwise. It has a similar effect as $D$ and is generally present in the Trade literature; $L$ is a dummy that is equal to 1 if countries $i$ and $j$ share the same language, 0 otherwise. We should expect lower costs per output of training and working with local employees if they speak and write the same language, and thus share a more similar culture, to the managers of the firm. It also reduces the additional costs due to marketing, advertising or packaging; Finally, $X_s$ is a set of dummy variables capturing whether the countries $i$ and $j$ are part of a monetary union, a free trade area or a single currency area at time $s$. That could influence the costs per output through lower tariff barriers, administrative costs and transaction costs of switching currencies for the single currency areas.

We have thus determined the optimal response of a representative firm. If we now take into account the whole economy, constituted by $aY_{si}^{N}$ firms which is a non-restrictive function of the size of the home country at time $t$ $Y_{si}$. Then, the total amount of outward FDI should be

$$FDI_s = aY_{si}^{N}\left[\frac{1}{\beta}Y_{sj}^{\mu}Z_s \exp\left(-\frac{1}{2}AE_s(\sigma^2_c)\right)\right]^{\frac{1}{1+\phi}}$$

(16)

where $\alpha > 0$ captures the reaction of a larger economy on outward FDI. Taking the logarithms of both sides to express the growth of FDI and gathering the terms, the equation becomes

$$\ln(FDI_s) = \gamma_1 + \gamma_2 E_s(\sigma^2_c) + \gamma_3 \ln(Y_{sj}) + \alpha \ln(Y_{si}) + \phi D + \Psi B + \varphi L + \sum \eta_i X_s$$

(17)

with $\gamma_2$ is expected to be negative because of the trade-off between exporting capital and exporting goods combined with the risk-aversion of the firm. Fundamentally, although investing abroad allows the firm to benefit from lower costs per output on average, these costs become stochastic due to the randomness of the exchange rate and will thus influence the choice between investing or exporting.

3 Empirical Strategy

The regression that we estimate is thus as follows:

$$fdi_{ij,t} = \gamma_1 + \gamma_2 E_s(\sigma^2_c) + \gamma_3 y_{ij,t} + \gamma_4 y_{i,t} + \phi D_{ij} + \Psi B_{ij} + \varphi L_{ij} + \eta_1 FTA_{ij,t} + \eta_2 EMU_{ij,t} + \omega_{ij} + \tau_t + \nu_{ij,t}$$

(18)
where $fd_{ij,t}$ is the log value of the outward FDI flow from country $i$ to $j$ at time $t$ and $E(\sigma^2_{eij,t})$ is a measure of expected bilateral exchange rate volatility at time $t$, computed as the standard error of the first difference of the log of the monthly nominal exchange rate in the five years preceding the current year. Then, $y_{j,t}$ corresponds to the log GDP of the host country $j$ at time $t$, $y_{i,t}$ corresponds to the log GDP of the source country $i$ at time $t$, and $D_{ij}$ is the distance between the two countries. As for the dummies, $B_{ij}$ accounts for two countries having a common border, $L_{ij}$ is a dummy for common language, $FTA_{ij,t}$ is a dummy equal to 1 if both countries subscribe to a Free Trade Agreement, and $EMU_{ij,t}$ is a dummy variable that has the value 1 if both countries are members of the European Monetary Union. In addition, $\omega_{ij}$ captures a pair-wise specific effects, $\tau_t$ controls for time specific effects and $\nu_{ij,t}$ is the error term.

To perform the empirical analysis, we have compiled a substantial dataset that covers 28 OECD countries over the period 1982-2002. This potentially corresponds to 15678 observations in the bilateral panel format, although 6407 observations only can be used due to missing data (see Table 1 for the descriptive statistics). The panel is unbalanced, with the number of observations per pair of countries ranging from a minimum of 12 to a maximum of 529 (and an average of 256). We believe that a panel framework will provide precise results since country data presents both large within and between variation, as Figures 1 & 2 seem to indicate for Italy, chosen as a representative country. Regarding the sources, data for this study are taken from the International Direct Investment Statistics Yearbook 2003 (OECD) for FDI flows, International Financial Statistics 2003 (IMF) for bilateral exchange rates, and from World Development Indicators 2003 for the control variables.

4 Results

The choice of the best model to use for this kind of analysis is highly debated and there is to date no real consensus. Therefore, we have decided to report, in Table 2, coefficient estimates for four separate model specifications using the regressors as exogeneous. These models differ based on: whether time effects have been controlled for, either with time dummies or a time trend; whether random or fixed effects have been estimated; and, most importantly, whether the exchange rate volatility’s marginal effect on FDI outflows is considered to be constant or dynamic. Then we take into consideration the endogeneity of some of the explanatory variables in Table 3 and offer different specifications, depending on the lag levels in the instrument matrix and the number of steps included in the estimation.

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6This includes the European Free Trade Association (EFTA), the Central European Free Trade Agreement (CEFTA), the Australia-NZL Closer Economic Relations, the European Economic Area (EEA) and the North American Free Trade Agreement (NAFTA).

711 countries were part of the EMU when it was formed in 1999 - Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain - while Greece has been a member since 2001.

8Australia, Austria, Belgium-Luxembourg, Canada, Czech Republic, Denmark, Finland, France, Germany, Great Britain, Greece, Hungary, Iceland, Ireland, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, South Korea, Switzerland, Turkey, and the United States.
4.1 Analysis over the Whole Period with Standard Regressions

Let us start by considering the estimate of the expected exchange rate volatility of the model \( B \) in Table 2. With GLS Random Effects, the results clearly highlight the fact that the effect of exchange rate risk is significantly different from zero in OECD countries over the 1982-2002 period. Moreover, if we focus on the economic interpretation of the statistic, we observe that the negative effect of exchange rate risk on FDI is highly significant: when the volatility estimated over the previous 60 months was lowered by 1 point, annual FDI outflows has increased by 2.4\% on average. In fact, because annualized volatilities in OECD countries range between 0 and 19, it seems that there is still plenty of room for increasing FDI flows through lower exchange rate risk. Testing this effect implicitly relates to testing the significance of the firm’s risk-aversion towards currency risk. If the estimate were accurate, we could then claim that because firms present a certain risk-aversion and because they are on average not able to fully hedge their risk or at a certain cost, such an uncertainty therefore plays an important role in operational decisions.

4.1.1 The Random vs the Fixed Effects Model

Although the results of the previous analysis are based on a model with random effects, a comparison of specifications \( A \) vs \( B \) in Table 2 suggests that there is little difference between a random and a fixed effects model. This is confirmed by performing a Hausman test on the difference between these two models, where we cannot reject the null hypothesis suggesting that there is no systematic difference\(^9\). However, although both the fixed and the random effects models are consistent, only the latter one can be deemed to be efficient. Moreover, it should be recalled that fixed effects models support neither heteroskedastic nor serially correlated disturbances, do not take into account the important between information provided by the panel dataset, lead to a loss of degree of freedom, offer poor out of sample prediction, and do not allow interesting time-constant variables such as distance, common border and common language to be considered. In light of this, we believe that a random effects model should lead to more efficient results and offer greater analytical power, should all right-hand side variables be exogeneous.

4.1.2 The Necessity of the Time Effects

While graphically analyzing the evolution over time of the aggregated exchange rate volatility in Figure 3 and outward FDI in Figure 4, one can easily observe two opposite trends: a clear negative trend for the former variable and a clear positive trend for the latter one. It is plausible that a decrease over time of exchange rate volatilities has fostered FDI flows. However, it is unlikely that the upward trend of outward FDI is only due to this decrease in exchange rate risk - and of the naturally positive trends of the countries’ GDP. Not controlling for time effects may well overstate the contribution of the currency risk - through its reversed trend - since the increasing trend of FDI flows could actually be due to other factors. We wish to avoid the observed estimate incorporating

\(^9\)This means that the fixed effects are significantly uncorrelated with each of the explanatory variables considered in the model.
spurious explanatory information from other variables and thus believe that taking into account yearly time effects, either with time dummies or a time trend, help the model overcome such a potential problem.

4.2 Evolution of the Relationship over Time

One would probably have expected this effect to be smaller though, should one consider the effective use of FOREX derivatives in removing some of the exchange rate risk exposure. A possible explanation of this finding is that we consider a dataset starting in the early 1980s, when the derivatives market was still in the years of infancy. While in the 1980s, many of the cash managers in multinationals did not have either the access or proper knowledge to fully exploit hedging possibilities, we should expect the opposite to be observed today. Using an average estimate covering the 1982-2002 period might thus lead to seriously misleading conclusions. Therefore, only an analysis of the evolution of the effect of exchange rate uncertainty on FDI could provide a more accurate picture.

As presented in Table 2 (Model C), a way of testing the dynamic effect is to consider an interaction between the exchange rate volatility effect and a time trend. For the purpose of obtaining a sound analysis, we only focus on the 1990-2002 period since no clear trend can be observed between 1982 and 1989, which is probably due to the lack of sufficient data. Unsurprisingly, the results of the Model C 10 confirm the decreasing significant marginal effect of exchange rate uncertainty on FDI outflows. Nevertheless, the Model C imposes a linear relationship over time that is not necessarily true. Therefore, a more accurate approach is to approximate a non-linearity by a quadratic effect, such as considered in Model D. The regression thus becomes

$$fdi_{ij,t} = \gamma_1 + \Phi X_{ij,t} + \gamma_2 E(\sigma^2_{eij,t}) + \eta_1 \left[ t * E(\sigma^2_{eij,t}) \right] + \eta_2 [t * E(\sigma^2_{eij,t})]^2 + \omega_{ij} + \tau_t + \nu_{ij,t}$$  (19)

with the vector $X_{ij,t}$ incorporating the other relevant variables previously considered. Although we can directly observe the significance of coefficients $\eta_1$ and $\eta_2$, analyzing and interpreting the dynamic of the effect is not particularly obvious. For this purpose, the evolution of the marginal effect of the exchange rate volatility on FDI has been computed in Figure 5. Not only the negative effect is indeed decreasing over time, but its pace is also accelerating, which emphasizes the importance of the quadratic term. One more time, our analysis - considering exogeneous exchange rate volatility - highlights the strongly decreasing effect that exchange rate uncertainty has had on FDI flows during the last decade.

We believe that this pattern is probably explained by the fact that multinationals are more and more able to benefit from the use of FOREX derivatives to limit their exposure to currency

\footnote{Note that model with a time trend instead of time dummies, present nearly identical results compared to model C. This allows us to claim that both a time trend and time dummies play a very similar role when the model needs to be controlled for time.}
risk. A natural reason is that cash managers are getting better trained to benefit from this type of market and that access is far more widespread. Another reason is that, since the value of hedging derivatives - except for currency swaps - is a positive function of the exchange rate volatility, a greater currency risk implies a higher cost of hedging. With decreasing volatilities over time as shown by Figure 3, trading FOREX derivatives thus gets much less costly over time. Moreover, the incentive for a "wait & see" strategy, coming from the option pricing theory, gets less important when the volatility decreases. This rationale may then explain why profit-maximizing firms present decreasing risk-aversion towards exchange rate uncertainty when the volatility follows a decreasing trend.

4.3 Endogeneity Issues

At this point, we may raise the question of the potential endogeneity issue. For instance, it is plausible that governments may try to reduce the exchange rate risk that multinationals encounter (through lower exchange rate volatility) in order to attract future expected foreign investment flows. In that setting, multinationals would exert pressure on a government to lower the exchange rate risk against a promise to invest in this country later on. If this were true, FDI flows would indeed have a negative effect on exchange rate volatility. Unfortunately, it is problematic to verify the validity of such an assumption because of the lack of relevant data. Another endogeneity story could also be the one proposed by Russ (2005) in her theoretical model of a multinational firm’s response with endogenous exchange rate driven by macroeconomic variables, with a sunk cost and nominal rigidity. She argues that because exchange rates and FDI are jointly determined by underlying macroeconomic factors, regressing FDI flows on exchange rate volatility may be subject to bias. It is possible to econometrically verify the existence of such a bias and, as a way of testing, the use of a GMM dynamic panel data estimator developed in Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1997) naturally arises. For this purpose, we consider here a system GMM estimator which combines the equation in differences - instrumented with lagged levels of regressors - with the equation in levels, instrumented with lagged differences of the regressors. We also compute robust two-step standard errors - asymptotically robust to both heteroskedasticity and serial correlation - by following the methodology proposed by Windmeijer (2004), which corrects the downward bias in small sample. Using "internal" instruments to deal with the correlation between the lagged endogenous variable and the time-invariant component of the disturbance, this approach addresses the issues of joint endogeneity of the explanatory variables in a dynamic setting and of potential biases coming from pair-wise specific effects. In our estimation, we assume the volatility

\[11\text{This approach is an improvement of the difference GMM estimator proposed by Arellano and Bond (1991), which only considers as predetermined instruments the lagged values of the levels of the explanatory variables. The problem arises when the regressors display persistence over time because their lagged levels thus become very poor instruments for their differences.}\]

\[12\text{This approach is theoretically superior to relying on the commonly used one-step estimates and standard errors since only the two-step estimator is asymptotically efficient. However, results are very similar in our case when we consider the one-step estimation. See Bond (2002) for a description of the methodology.}\]
of the exchange rates, the log of GDP of both the source and the host countries and of course the log of Outward FDI to be potentially endogenous.

Without going into the details, we consider the same equation as before except that we include the lagged dependent variable:

\[
\begin{align*}
fdi_{ij,t} - fdi_{ij,t-1} &= \gamma_1 + (\alpha - 1)fdi_{ij,t-1} + \Phi X_{ij,t} + \gamma_2 E(\sigma^2_{eij,t}) \\
+ &\eta_1 [t * E(\sigma^2_{eij,t})] + \eta_2 [t * E(\sigma^2_{eij,t})]^2 + \omega_{ij} + \tau_t + \nu_{ij,t}
\end{align*}
\]  

(21) \hspace{1cm} (22)

As long as the model is overidentified, validity of the assumptions underlying the system estimator can be tested through Hansen or Sargan tests of orthogonality between the instruments and the residuals, and through tests of (first and second order) residual correlations. The results in Table 3 show that the validity of the instruments cannot be rejected and that we can safely reject any second order serial correlation, which constitutes a necessary condition for the consistency of the estimation. However, Baum et al. (2003) showed that such tests may fail to detect the lack of validity of a subset of instruments. Nevertheless, while re-estimating the regression with one, two or three lag levels in the instrument matrix, the estimation still yields very similar results and thus insures that our results are robust. For instance, results are fairly similar between a lag structure starting at t-1 (tested but not presented), t-2 or t-3 as obtained in Model E and Model F. In addition, the estimation does not seem to be sensitive to the procedure considered, as shown by the comparison of Model E, estimated with the predescribed two-step procedure, and Model G, using 2SLS as the one-step estimator.

On the whole (see Models E, F, and G), the parameters are very well determined and corroborate with our previous findings. However, although the exchange rate volatility carries the same sign as before, the estimate is no longer significant. The results are then much less strongly supportive of a negative impact of exchange rate volatility on FDI outflows when we assume some of the explanatory variables to be endogenous. We can thus conclude that the endogeneity of the exchange rate volatility could be as dramatic as the theoretical model of Russ (2005) emphasized. Even if she assumes that firms are not allowed to hedge against fluctuations of the exchange rate in her model, we indeed observe a severe downward bias - in both the estimates and the standard errors - due to endogeneity of the exchange rate volatility, as well as of the GDP growth of both the sending and the recipient countries.

While moving to the analysis of the exchange rate volatility effect over time (for the 1990-2002 period, as before), Model H highlights the presence of the decreasing effect already captured in the GLS regression of Model D. The system GMM seems to even capture a sign change in the influence of exchange rate uncertainty on FDI flows which may offer an explanation on the insignificance of the average estimate. As easily observed in Figure 6, the impact is negative in the early 1990s and then positive from the mid-1990s, which suggests a much larger change (a steeper slope) of the effect over time. We can thus reject, at least in our case, the argument of Aghion et al (2006) that
endogeneity is much less of an issue with an interaction term than with single variables. Indeed, the bias gains of importance with the size of the variable (the time trend here) the exchange rate volatility is interacted with.

Very interestingly, a slight modification of our simple theoretical framework is fully able to capture the pattern just observed. Indeed, assume the existence of some unexpected exogeneous macroeconomic or political shocks \( p_t \) affecting the production side at time \( t \) and with the following logarithmic distribution

\[
\ln \left( \frac{p_t}{p_s} \right) \sim N(0, \sigma_p^2)
\]  

We can reasonably assume that these shocks affect both the net profit \( \pi^{net} \) and the exchange rate \( e_t(p_t) \) at each period such that equation (5) becomes

\[
\pi^{net} = \pi_{FDI} - \pi_{Export} = \sum_{t=s}^{\infty} \frac{1}{(1+r)^{t-s}} \left[ \frac{p_t}{p_s} Q_{jt} (c_{jt} - \frac{e_t(p_t)}{e_s c_{jt}}) \right] - FDI_s
\]  

and the correlation between the political shocks and the exchange rate is given by \( \text{corr}(e_t, p_t) = \rho < 0 \). For instance, a positive shock may come from an increase of the permanent foreign money supply, thus increasing total output in the foreign country and lowering the exchange rate.

From Laplace transform, we know that

\[
E \left[ \frac{p_t}{p_s} \frac{e_t}{c_s} \mid F_s \right] \simeq \exp \left( \frac{1}{2} A E_s \left[ \sigma_e^2 \right] + \frac{1}{2} B E_s \left[ \sigma_p^2 \right] + \text{cov}(e_t, p_t) \right) \quad \text{with } A, B \geq 0
\]  

where \( A \) and \( B \) are respectively functions of the coefficient of exchange rate and political constant risk-aversion of the representative firm. Then, considering the certainty equivalent level of net profits along the new political shocks, we obtain:

\[
E \left[ \pi^{net} \mid F_s \right] = \sum_{t=s}^{\infty} \frac{1}{(1+r)^{t-s}} E \left[ \pi \mid F_s \right] - FDI_s \quad \text{with}
\]

\[
E \left[ \pi \mid F_s \right] = E \left[ \frac{p_t}{p_s} \mid F_s \right] Y_{s_j}^\beta c_i - \left( Y_{s_j}^\beta \exp \left( -\frac{1}{2} A E_s \left[ \sigma_e^2 \right] - \frac{1}{2} B E_s \left[ \sigma_p^2 \right] + \text{cov}(e_t, p_t) \right) \right) \Psi c_i Z_s FDI_s^{-\beta}
\]  

By deriving the First Order Condition and using the property \( \text{corr}(a, b) = \text{cov}(a, b) \mid \text{var}(a) \text{var}(b) \)^{-1/2}, we can obtain the optimal amount of \( FDI_s \) with respect to the exchange rate volatility and the exchange rate volatility coincides with the choice of some policies associated with future FDI flows unaccounted for by the regressors. This could directly bias our concerned estimator in a linear estimation set up. However, in their argument, this could bias the estimation of the interaction coefficients in our model only to the extent that the correlation between such policies and exchange rate volatility significantly increases over time.
political shocks:

\[ FDI_s = \left[ \frac{1}{\sqrt{\pi}} Y_{sj} Z_s \exp\left( -\frac{1}{2} AE_s \left[ \sigma^2 \right] - \frac{1}{2} BE_s \left[ \sigma^2_p \right] - \rho E_s \left[ \sigma^2 \right] \right) \right] \mathcal{N}(1) \]  

(29)

Hence, the new marginal impact of the endogeneous exchange rate uncertainty on log FDI flows is

\[ \frac{\partial f_{di_s}}{\partial E_{s}[\sigma^2]} = \gamma_2 - \frac{\rho}{2(1+\beta)} \sqrt{\frac{E_s[\sigma^2]}{E_s[\sigma^2]}} > \gamma_2 \quad \text{if} \quad \rho < 0 \quad (\gamma_2 < 0) \]  

(30)

As the result points out, when we take into consideration an exogenous (political) shock to affect future profits as well as the exchange rate, the impact of \( E_s[\sigma^2] \) is less negative than what the initial model predicted. There seems to be a potential bias that is corrected here. This is exactly what we obtain in the empirical results. Moreover, an even more striking fact is that for a low enough exchange rate volatility, the marginal influence on FDI flows may be positive. Indeed, below the threshold level

\[ 0 < E_s[\sigma^2] < \left[ \frac{\rho E_s[\sigma^2] \gamma^2}{2(1+\beta)\gamma_2} \right] \]  

(31)

an increase in the exchange rate volatility improves FDI flows because of the negative correlation between the exchange rate and the political shocks. It is then beneficial to increase foreign investment since the exchange rate exposure provides an hedge against unexpected political shocks. Therefore, a decreasing average exchange rate volatility over time - as seen in Figure 3 - should naturally engender the effect on FDI flows to weaken over time through an increase in the endogeneity bias

\[-\frac{\rho}{2(1+\beta)} \sqrt{\frac{E_s[\sigma^2]}{E_s[\sigma^2]}} > 0. \]  

This perfectly corroborates the empirical findings.

We are then clearly able to highlight and verify the hypothesis that panel estimations with OLS Fixed Effects and GLS Random Effects seem to engender a severe downward bias of the estimates and provide too small standard errors in presence of endogeneous explanatory variables. According to both the empirical and the theoretical findings, this is especially the case in the more recent years with a decreasing level of exchange rate risk.

5 Robustness and Sensitivity Analysis

A substantiated criticism of the model lies with the number of data observations used in its estimation. As noted earlier, there are 15876 potential data points in our dataset. However, the fact that only 6407 are used highlights an underlying problem of our empirical work – that of missing data. Due to the large number of missing values contained within the FDI variable, it seems important to check that our results do not hold only for a particular period or sub-sample. We thus attempt to address this concern with Table 4, reporting four sensitivity checks used to test the robustness of
our results\textsuperscript{14}.

In analysis \textit{I}, we include a variable capturing the difference in wages between the source and the host country to implicitly test the soundness of the empirical model explaining FDI flows between North-North countries. Since we are interested in FDI flows among industrialized countries, we assumed that firms try to capture part of a foreign market. Thus, if multinationals are not to consider FDI between OECD countries as a means of outsourcing their production\textsuperscript{15}, the explanatory power of this new variable should be insignificant. Whilst the estimate is significantly different from zero, the alteration of the model does not lead to any changes in the coefficients of other variables. Moreover, since an increase of 10,000 USD difference in per capita income has fostered FDI flows by a mere 1\%, the effect can be thought of as economically non-existent. This suggests that the model is indeed robust and sound in explaining FDI flows between industrialized countries.

Analysis \textit{J} alters the sample under study by excluding data observations for the 1980s. This is justified on the grounds that the majority of missing observations are concentrated in the early part of the sample, and that the 1980s represented a period of high exchange rate volatility. Once the 1980s data are removed from the sample, the coefficient suggests that the influence of a 1\% decrease in the exchange rate volatility increases FDI by 3.3\% rather than 2.4\%. All other coefficients remain identical in terms of sign and significance, and also bear a strong resemblance to the benchmark model \textit{B} in terms of size – thus suggesting robust results.

Analysis \textit{K} changes the sample by excluding all countries that are designated as ‘low income’ - defined by whether average GDP per capita was below $15,000 for the period 1982-2002. This leaves 18 of the 28 countries in the sample\textsuperscript{16}, but retains the majority of FDI data observations, suggesting that low income countries are data scarce. Again, all results maintain their sign and level of significance, although the effect of currency risk seems to gain importance. In the high-income sample, the benefits of lower exchange rate uncertainty are associated with a 3.8\% increase in FDI for each 1\% drop in the volatility – more than 150\% the effect suggested in our benchmark model. This could reflect the fact that lower income countries suffer less from fluctuations in the exchange rates than higher income countries.

Finally, in analysis \textit{L}, we change the sample by excluding all data scarce countries – defined by those countries missing more than two thirds of their FDI data\textsuperscript{17}. As previously indicated, this leads to the omission of the majority of lower income countries. Nevertheless, the sign and significance of the coefficients remains unaltered and the influence provided by the exchange rate volatility mimics the effect observed in the benchmark case.

\textsuperscript{14}The robustness checks are based on the GLS Random Effects and the estimates are thus subject to potential bias because of the endogeneity issue. However, the goal here is only to verify the consistency of the dataset and to check if outliers drive the results. An analysis with a system GMM would provide similar conclusions.

\textsuperscript{15}This would occur in North-South flows, since multinationals mainly invest in developing countries to benefit from lower wages rather than looking for an expansion of their market.

\textsuperscript{16}The ‘lower income’ countries in the sample were the Czech Republic, Greece, Hungary, Korea, Mexico, New Zealand, Poland, Portugal, Spain, and Turkey.

\textsuperscript{17}The thirteen data scarce countries in the sample were Australia, Belgium, Czech Republic, Denmark, Greece, Hungary, Ireland, Mexico, New Zealand, Poland, Portugal, Spain and Turkey.
6 Conclusions

The results of this paper suggest that simple panel estimations with OLS Fixed Effects or GLS Random Effects point out a robust negative relationship between expected exchange rate uncertainty and FDI over the 1982-2002 period. For instance, the sign of that average estimated effect of exchange rate volatility mimic the Bénassy-Quéré et al. (2001) panel-data work, although their data set is different to ours, since these authors focus on North-South flows of FDI while we only consider OECD countries in our analysis. Similar results are also found in a more comparable study, proposed by Chakrabarti and Scholnick (2002), in which they consider FDI flows from the U.S. to 20 OECD countries.

Unfortunately, most of such studies analysing FDI flows and exchange rate volatility are subject to potentially severe endogeneity bias which are generally not empirically accounted for. One potential problem is that exchange rate volatility may be linked with other important firm characteristics such as projected sales, which are together determined by underlying macroeconomic variables (Russ, 2005). Theoretically, this suggests that standard regressions of FDI on exchange rate volatility are potentially downward biased due to such an endogeneity. For this purpose, we consider in this paper a system GMM Dynamic Panel Data estimation to control for the endogeneity of the exchange rate volatility as well as of the home and the host countries GDPs. The main contribution of this paper is thus to both theoretically and empirically highlight the importance of the bias, leading to a statistically insignificant corrected average estimate. Our conclusions remain the same when considering different lag levels in the instrument matrix or when using either one-step or two-step estimators, thus insuring the robustness of our finding. The novelty of this study is also to provide evidence, in our dynamic setting, that the negative influence of the exchange rate uncertainty on FDI flows is decreasing over time and even turns out to be positive in the second part of the 1990s.

The fact that multinationals in industrialized countries have presented in the 1990s, on average and at the aggregated level, a decreasing impact from currency risk may be due to a greater availability of hedging opportunities, thus offering a reduction of the risk exposure. However, this hypothesis cannot explain the puzzling observation that the influence has even become positive since the mid-1990s. However, our simple theoretical model provides evidence that this pattern is due to the decreasing level of exchange rate risk over time coupled with the negative correlation between unobserved shocks and the exchange rate. Hence, the estimated role that volatility of the exchange rates seemed to play in multinationals’ decisions regarding FDI is rather ambiguous, once considering a comprehensive dataset and an appropriate econometric approach. Theoretically, the estimate highly depends on the level of the exchange rate volatility.

Among others, a criticism of the paper is that firms - as in the theoretical model - may not use exchange rate uncertainty as its sole measure of risk when making investment decisions. Also important is the political stability of a country and the stability of the economy. An improvement for further work might therefore be to empirically include proxies for these or similar kinds of country risk. It would also be interesting to take into consideration the flows of intermediate goods and
to consider the fluctuations of demand shocks in the foreign market. These could be proxied, for example, by the volatility of a foreign country’s stock exchange index. Clearly, we are just beginning to really understand the relationship between FDI and exchange rate risk.
References


Appendices

Figure 1: Bilateral Exchange Rate Volatilities for Italy with 15 Countries, 1982-2002

The figure represents the dynamic of the bilateral exchange rate volatility, between Italy (chosen as a representative country) and an arbitrary selection of 15 OECD countries over the 1982-2002 period, computed as the standard error of the first difference of the log of the monthly nominal exchange rate in the five years preceding the current year. The figure suggests that a panel framework seems appropriate for our analysis since there exists some important variation over time, as well as between pair of countries, in the bilateral exchange rate volatilities.
Figure 2: FDI Outflows from Italy towards Other Countries, 1982-2002

The figure represents the dynamic of the Foreign Direct Investment outflows from Italy towards an arbitrary selection of 15 OECD countries over the 1982-2002 period. The figure thus suggests that a panel framework seems appropriate since there exists some important variation over time, as well as between pair of countries, in the bilateral flows between the chosen representative country and 15 other OECD countries.
Figures 3 & 4: Average Exchange Rate Volatility and FDI Outflows, 1982-2002

The figures show the sample average dynamic of the Foreign Direct Investment outflows and bilateral exchange rate volatility over the 1982-2002 period. The figures suggest a clear positive trend for the former series and a clear negative trend for the latter one. Because it is unlikely that the upward trend of outward FDI is only due to this decrease in exchange rate risk, not controlling for time effects may well overstate the contribution of the currency risk - through its reversed trend - since the increasing trend of FDI flows could actually be due to other factors. We wish to avoid the observed estimate incorporating spurious explanatory information from other variables. It is thus necessary to control for time effects in our model, either with time dummies or with a time trend.

The figures provide an analysis of the evolution of the effect of exchange rate uncertainty on FDI, which should provide a more accurate picture than considering an average effect for the period. We test the dynamic effect by considering an interaction between the exchange rate volatility effect and a time trend as well as a quadratic effect to approximate a non-linearity in the relationship (see Table 2 & 3 for the comprehensive results). Using 95% level of confidence bounds, the figures highlight a less negative effect over time for both estimations. More importantly, the effect that exchange rate uncertainty has had on FDI flows during the last few years has become insignificant for the GLS Random-Effects model, while even positive for the system GMM Dynamic Panel Data estimator.
In the following tables, we perform an empirical analysis on 28 OECD countries over the period 1982-2002: Ln FDI Outstock captures the logarithm value of the outward FDI flow between the source and the host country, Exchange Rate Volatility is a measure of expected bilateral exchange rate volatility computed as the standard error of the first difference of the log of the monthly nominal exchange rate in the five years preceding the current year. Ln GDP Source corresponds to the GDP of the source country, Ln GDP Host corresponds to the GDP of the host country, and Distance is the distance between the two countries. As for the dummies, Common Border accounts for two countries having a common border, Common Language is a dummy for common language, Both in FTA is a dummy equal to 1 if both countries subscribe to a Free Trade Agreement, and Both in EMU is a dummy variable that has the value 1 if both countries are members of the European Monetary Union. In the regressions we also control for pair-wise specific fixed or random effects as well as for time specific effects. Data sources are the International Direct Investment Statistics Yearbook 2003 (OECD) for FDI flows, International Financial Statistics 2003 (IMF) for bilateral exchange rates, and from World Development Indicators 2003 for the control variables.

### Table 1: Table of Statistics

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Observations</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln FDI Outstock</td>
<td>6407</td>
<td>2.637</td>
<td>1.259</td>
<td>1</td>
<td>5.481</td>
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<tr>
<td>Exchange Rate Volatility</td>
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<td>2.624</td>
<td>0</td>
<td>19.148</td>
</tr>
<tr>
<td>Ln GDP Source</td>
<td>6407</td>
<td>11.324</td>
<td>.656</td>
<td>9.444</td>
<td>13.017</td>
</tr>
<tr>
<td>Ln GDP Host</td>
<td>6407</td>
<td>11.324</td>
<td>.656</td>
<td>9.444</td>
<td>13.017</td>
</tr>
<tr>
<td>Distance (Km)</td>
<td>6407</td>
<td>5507.88</td>
<td>5413.51</td>
<td>174.024</td>
<td>19868.12</td>
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<td>1</td>
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<td>Both in EMU</td>
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<td>.156</td>
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<td>6407</td>
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<td>.429</td>
<td>0</td>
<td>1</td>
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</table>

### Correlation matrix

<table>
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<tr>
<th></th>
<th>Ln FDI Outstock</th>
<th>Exchange Rate Volatility</th>
<th>Ln GDP Source</th>
<th>Ln GDP Host</th>
<th>Distance (Km)</th>
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<tr>
<td>Ln FDI Outstock</td>
<td>1</td>
<td>-.167</td>
<td>.558</td>
<td>.289</td>
<td>-.089</td>
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<td>1</td>
<td>.088</td>
<td>-.126</td>
<td>.365</td>
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<tr>
<td>Ln GDP Source</td>
<td>.558</td>
<td>.088</td>
<td>1</td>
<td>.124</td>
<td>.151</td>
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<td>Ln GDP Host</td>
<td>.289</td>
<td>-.009</td>
<td>-.126</td>
<td>1</td>
<td>.124</td>
</tr>
<tr>
<td>Distance (Km)</td>
<td>-.089</td>
<td>.365</td>
<td>.151</td>
<td>.124</td>
<td>1</td>
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### Table 2: Exchange Rate Volatility Effects on FDI with Pooled OLS-GLS Estimation: Random Effects GLS and Fixed Effects OLS with Time Effects

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Ln FDI Outward</th>
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<tr>
<td><strong>Model</strong></td>
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<td><strong>Functional form</strong></td>
<td>Linear</td>
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<td>Exchange Rate Volatility</td>
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</tr>
<tr>
<td>-0.022</td>
<td>-0.024</td>
</tr>
<tr>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Exchange Rate Volatility Interacted with Time Trend</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>$10^2 \times (\text{Exchange Rate Volatility Interacted with Time Trend})^2$</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Ln GDP Source</td>
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</tr>
<tr>
<td></td>
<td>(0.093)</td>
</tr>
<tr>
<td>Ln GDP Host</td>
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</tr>
<tr>
<td></td>
<td>(0.083)</td>
</tr>
<tr>
<td>Distance (1000 km)</td>
<td>dropped</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Common Language</td>
<td>dropped</td>
</tr>
<tr>
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<td></td>
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<tr>
<td>Common Border</td>
<td>dropped</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Both in EMU</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
</tr>
<tr>
<td>Both in FTA</td>
<td>0.096</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
</tr>
<tr>
<td>Time Trend</td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
</tr>
<tr>
<td>R² Within</td>
<td>0.55</td>
</tr>
<tr>
<td>R² Between</td>
<td>0.38</td>
</tr>
<tr>
<td>R² Overall</td>
<td>0.46</td>
</tr>
<tr>
<td>Number of observations</td>
<td>6407</td>
</tr>
<tr>
<td>Fixed Effects^{D}</td>
<td>Yes</td>
</tr>
<tr>
<td>Random Effects^{D}</td>
<td>Yes</td>
</tr>
<tr>
<td>On Time</td>
<td>Yes</td>
</tr>
<tr>
<td>Time trend</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Notes:**

- Standard errors reported in parentheses.
- ^{a}, ^{b}, ^{c} relate to coefficients respectively significant at the 95, 99, 99.9% confidence level.
- In order to control for both source and recipient country effects, a pair-wise index was created that assigns a unique identifier to each country’s FDI with every other country. In the three country case, this measure will assign six different identifiers: 1) X/Y; 2) Y/X; 3) X/Z; 4) Z/X; 5) Y/Z; and 6) Z/Y.
**Table 3: Exchange Rate Volatility Effects on FDI with Dynamic GMM**

*Estimation:* 2-step system GMM estimation (except Model G) with Windmeijer (2005) Finite Sample Robust Correction and Time Effects

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Ln FDI Outward</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td>E</td>
</tr>
<tr>
<td><strong>Lag structure</strong></td>
<td>t-2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exchange Rate Volatility</th>
<th>-0.015</th>
<th>-0.020</th>
<th>-0.012</th>
<th>-0.075*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.009)</td>
<td>(0.021)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exchange Rate Volatility Interacted with Time Trend</th>
<th>0.016*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.005)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10^2*(Exchange Rate Volatility Interacted with Time Trend)</th>
<th>-0.006</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.007)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ln GDP Source</th>
<th>1.235*</th>
<th>1.279*</th>
<th>1.142*</th>
<th>1.184*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.062)</td>
<td>(0.059)</td>
<td>(0.074)</td>
<td>(0.073)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ln GDP Host</th>
<th>0.776*</th>
<th>0.843*</th>
<th>0.786*</th>
<th>0.680*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.093)</td>
<td>(0.095)</td>
<td>(0.097)</td>
<td>(0.113)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distance (1000 km)</th>
<th>-0.017</th>
<th>-0.013</th>
<th>-0.036*</th>
<th>-0.007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.012)</td>
<td>(0.012)</td>
<td>(0.013)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Common Language</th>
<th>1.436*</th>
<th>1.514*</th>
<th>1.283*</th>
<th>1.533*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.172)</td>
<td>(0.176)</td>
<td>(0.175)</td>
<td>(0.205)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Common Border</th>
<th>1.095*</th>
<th>0.996*</th>
<th>0.263</th>
<th>1.739*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.396)</td>
<td>(0.374)</td>
<td>(0.383)</td>
<td>(0.535)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Both in EMU</th>
<th>0.212*</th>
<th>0.221*</th>
<th>0.116</th>
<th>0.474*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.103)</td>
<td>(0.098)</td>
<td>(0.067)</td>
<td>(0.147)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Both in FTA</th>
<th>0.491*</th>
<th>0.599*</th>
<th>0.483*</th>
<th>0.472*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.104)</td>
<td>(0.114)</td>
<td>(0.091)</td>
<td>(0.125)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specification tests (p-values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Hansen Test</td>
</tr>
<tr>
<td>(b) First-Order Correlation</td>
</tr>
<tr>
<td>Second-Order Correlation</td>
</tr>
<tr>
<td>Number of instruments</td>
</tr>
<tr>
<td>Number of observations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimation structure</th>
<th>2-step</th>
<th>2-step</th>
<th>1-step</th>
<th>2-step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearly Time Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Notes:**

- Standard errors reported in parentheses.
- *a, b, c* relate to coefficients respectively significant at the 95, 99, 99.9% confidence level.
### Table 4: Sensitivity Analysis

**Estimation:** Random Effects GLS with Time Effects

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensitivity Analysis</strong></td>
<td>Wage differential between countries included</td>
<td>Excluding 1980s data</td>
<td>Excluding low income countries</td>
<td>Excluding data scarce countries</td>
</tr>
<tr>
<td>Exchange Rate Volatility</td>
<td>-0.024&lt;sup&gt;c&lt;/sup&gt; (0.003)</td>
<td>-0.033&lt;sup&gt;c&lt;/sup&gt; (0.004)</td>
<td>-0.038&lt;sup&gt;c&lt;/sup&gt; (0.004)</td>
<td>-0.026&lt;sup&gt;c&lt;/sup&gt; (0.003)</td>
</tr>
<tr>
<td>Ln GDP&lt;sub&gt;Source&lt;/sub&gt;</td>
<td>1.340&lt;sup&gt;c&lt;/sup&gt; (0.044)</td>
<td>1.285&lt;sup&gt;c&lt;/sup&gt; (0.047)</td>
<td>1.036&lt;sup&gt;c&lt;/sup&gt; (0.043)</td>
<td>1.157&lt;sup&gt;c&lt;/sup&gt; (0.043)</td>
</tr>
<tr>
<td>Ln GDP&lt;sub&gt;Host&lt;/sub&gt;</td>
<td>0.856&lt;sup&gt;c&lt;/sup&gt; (0.046)</td>
<td>0.823&lt;sup&gt;c&lt;/sup&gt; (0.049)</td>
<td>0.897&lt;sup&gt;c&lt;/sup&gt; (0.044)</td>
<td>0.953&lt;sup&gt;c&lt;/sup&gt; (0.045)</td>
</tr>
<tr>
<td>Distance (1000 km)</td>
<td>-0.048&lt;sup&gt;c&lt;/sup&gt; (0.006)</td>
<td>-0.046&lt;sup&gt;c&lt;/sup&gt; (0.007)</td>
<td>-0.049&lt;sup&gt;c&lt;/sup&gt; (0.007)</td>
<td>-0.062&lt;sup&gt;c&lt;/sup&gt; (0.008)</td>
</tr>
<tr>
<td>Common Language</td>
<td>0.957&lt;sup&gt;c&lt;/sup&gt; (0.092)</td>
<td>0.944&lt;sup&gt;c&lt;/sup&gt; (0.094)</td>
<td>0.557&lt;sup&gt;c&lt;/sup&gt; (0.081)</td>
<td>0.551&lt;sup&gt;c&lt;/sup&gt; (0.025)</td>
</tr>
<tr>
<td>Common Border</td>
<td>0.428&lt;sup&gt;c&lt;/sup&gt; (0.125)</td>
<td>0.442&lt;sup&gt;c&lt;/sup&gt; (0.129)</td>
<td>0.394&lt;sup&gt;c&lt;/sup&gt; (0.115)</td>
<td>0.583&lt;sup&gt;c&lt;/sup&gt; (0.090)</td>
</tr>
<tr>
<td>Both in EMU</td>
<td>0.048 (0.026)</td>
<td>0.001 (0.026)</td>
<td>-0.043 (0.026)</td>
<td>-0.051 (0.027)</td>
</tr>
<tr>
<td>Both in FTA</td>
<td>0.119&lt;sup&gt;c&lt;/sup&gt; (0.021)</td>
<td>0.123&lt;sup&gt;c&lt;/sup&gt; (0.024)</td>
<td>0.121&lt;sup&gt;c&lt;/sup&gt; (0.019)</td>
<td>0.095&lt;sup&gt;c&lt;/sup&gt; (0.020)</td>
</tr>
<tr>
<td>10,000 $ Per Capita Income Differential</td>
<td>0.011&lt;sup&gt;c&lt;/sup&gt; (0.001)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**R²**

- **Within:** 0.55 0.39 0.59 0.60
- **Between:** 0.55 0.57 0.61 0.62
- **Overall:** 0.60 0.59 0.62 0.63

**Number of observations:** 6407 5113 5439 5385

**Notes:**

All sensitivity checks are performed on the benchmark random pair-wise and time effects model B.

<sup>a, b, c</sup> relate to coefficients respectively significant at the 95, 99, 99.9% confidence level.

Standard errors reported in parentheses.

1. Source countries with average GDP per capita below $15,000 over the period 1982-2002, are removed from the sample. This excludes the Czech Republic, Greece, Hungary, Korea, Mexico, New Zealand, Poland, Portugal, Spain, and Turkey from the analysis.

2. Countries with more than two thirds of their FDI data missing are removed from the sample. This excludes Australia, Belgium, Czech Republic, Denmark, Greece, Hungary, Ireland, Mexico, New Zealand, Poland, Portugal, Spain and Turkey.