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Key words – Foreign Direct Investment, Exchange Rates, CGARCH

JEL Classification: F31 – Foreign Exchange
F23 – Multinational Firms

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Identifying strategies for attracting foreign direct investment (FDI) has become a priority in many developing nations because FDI is generally viewed as better directed toward long run growth and economic prosperity. Since FDI tends to be motivated by a firm's prospects for making profits in production activities over the long-run, FDI is thought to imply a long-run commitment and is therefore viewed as a more stable source of financing than portfolio investment. Moreover, capital accumulation and technological spillovers that accompany FDI are thought to promote economic growth (see Benassy-Quere *et al*., 2001; Goldberg and Klein, 1997 and Urata and Kawai, 2000).

Despite the growing interest in FDI inflows, we are not well informed about FDI's response to the exchange rate and how various exchange arrangements may serve in attracting or deterring FDI to Latin America. This lack of understanding is particularly troubling given the diversity of exchange rate systems observed in Latin America. Smaller economies in the region have moved towards hard pegs in the form of dollarization. Given that dollarization is a relatively new strategy, its effect on FDI inflows remains to be seen. On the other hand, there has been a movement on the part of larger economies (the main recipients of FDI) towards flexible nominal exchange rate systems. This trend, along with persistent fluctuations in real exchange rates, have generated renewed interest in studying the impact of exchange rate changes and exchange rate uncertainty on international inflows including portfolio investment, worker remittances, and inward FDI.

In this paper, our goal is to investigate how exchange rate changes and exchange rate uncertainty affect U.S. direct investment flows into Latin America. To this end, we use data on U.S. direct investment into seven Latin American countries -- Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela -- for the 1994–2005 period.[i] In addition to currency returns and exchange rate uncertainty, we explore how U.S. GDP growth, host country GDP growth, openness, inflation, and exchange rate regimes impact FDI.

Though there are many studies that have examined the relationship between FDI and the foreign exchange market, fewer empirical studies consider the special case of developing countries.[ii] This paper explores the relationship between FDI and the exchange market while paying special attention to the effects of exchange rate uncertainty. We investigate whether the impact of exchange rate uncertainty is robust to different specifications. Furthermore, we decompose exchange rate uncertainty into short and long-run components using the CGARCH methodology proposed by Engle and Lee (1999).

The decomposition of exchange rate uncertainty into its transitory and permanent components enables us to isolate exchange rate volatility originating from the short-run international business cycle and short-term capital flows, from uncertainty originating from changes in economic fundamentals (see Black and McMillan, 2004 and Byrne and Davis, 2005). In addition to decomposing uncertainty into its transitory and permanent components, we are able to assess whether one or the other is more important in driving FDI decisions. In this inquiry we use panel data methods to exploit variations in flows both across countries and across time.

Section A of this paper presents the background, relevant literature and hypotheses regarding the impact of exchange rates on FDI. Sections B and C introduce the data and the methodology used. In section D we test for the effects of the exchange rate and its uncertainty on U.S. direct investment into Latin America. Finally, we conclude with a discussion of our results in Section E.

A. BACKGROUND AND RELEVANT LITERATURE

Given the nature of FDI, it is natural to consider the exchange rate as one of its central determinants. There are several hypotheses regarding how FDI flows respond to variations in the *level* of the exchange rate. In the so-called wealth position hypothesis, FDI is related to the foreign exchange markets through the impact of changes in the level of the exchange rate on the relative wealth of the two countries. The relative labor cost hypothesis, alternatively argues that depreciation of the foreign currency alters day to day production costs prompting changes in foreign investments.[iii]

Froot and Stein (1991) subscribe to 'relative wealth' as the link between FDI and exchange rate levels. Depreciation of a currency increases the relative wealth position of foreigners and lowers their relative cost for acquiring capital. In the presence of capital market imperfections and information asymmetry, real depreciations favor foreign purchasers of domestic assets and this is associated with an increase in inward FDI. Cushman (1985, 1988), in contrast, adheres to the second view. He argues that production costs are influenced by factors such as the real exchange rate, and as such focuses on the effects that currency movements have on relative labor costs. A real depreciation of the host country currency lowers the cost of FDI because it lowers wage and production costs. Investors pay attention to the real exchange rate as an indicator of production costs abroad with FDI representing capital seeking low cost labor facilities.

In general, most empirical studies find that a depreciation of the host country currency results in an increase in inward FDI (see Cushman, 1988; Froot and Stein, 1991; Klein and Rosengren, 1994; Bayoumi and Lipworth, 1998; Amuedo-Dorantes and Pozo, 2001; Sazanami, *et al*., 2003; and Kiyota and Urata, 2004). Only a handful of empirical studies have found that appreciations of the host country currency increases or have no effect on inward FDI (see Campa, 1993; Goldberg and Kolstad, 1995; Goldberg and Klein, 1997).

Another strand of the theoretical literature has developed around the work of Dixit (1989), and Dixit and Pindyck (1994), which stresses the role played by *uncertainty* in shaping investment decisions. This literature suggests that the combination of irreversible investment, uncertainty about the future benefits and costs of the investment project, and flexibility with investment timing, may cause a "wait and see" attitude in making investment decisions when there are increases in uncertainty about economic variables. Since investors necessarily look into the future before undertaking any investments, investors' behavior will be responsive to the degree of investment uncertainty about future prices, rates of return, and economic conditions. FDI, in particular, can involve substantial risk for multinational firms (MNFs). Besides the normal risks involved in carrying out any business, MNFs face the uncertainty of being located abroad.

The above-mentioned mode of thinking would lead us to expect a negative relationship between exchange rate uncertainty and FDI. If the purpose of FDI were either to serve other markets or bring production back to the home country, a negative relationship between FDI and exchange rate uncertainty would likely arise. A high degree of uncertainty would deter companies from making the initial investment in developing countries. It has alternatively been suggested that a positive effect is also a possibility, in particular if the purpose of FDI is to diversify the location of production and to have the option of production flexibility.

Given the differing hypotheses about the impact of exchange rate uncertainty on investment, recent empirical literature has shifted toward testing for the possible effects of volatility and real exchange rate uncertainty on FDI with the objective of sorting out these possibilities (see Sung and Lapan, 2000; Urata and Kawai, 2000; Benassy-Quere, *et al*., 2001 and Kiyota and Urata, 2004 for recent examples). As of yet, there is no consensus regarding the effects of exchange rate risk on FDI. Furthermore, most studies in this literature consider FDI flowing into developed countries. As such, in terms of developing countries -- in particular Latin American countries -- the role of exchange rate levels and exchange rate uncertainty in influencing FDI are yet to be established

B. DATA

The data used in this paper consists of a panel of quarterly observations for the 1994:1 to 2005:1 period. The countries in the panel are Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela. These countries account for over 85% of the incoming FDI into Latin America. We use the data on FDI reported by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce. It is derived from the statistics of the balance of payments and direct investment position data, and corresponds to U.S. direct investment disaggregated by host country.

Following a standard procedure in the literature, we scale nominal FDI by the nominal GDP of each country. This variable is what we use as our benchmark dependent variable. Using GDP as a deflator controls for both the size of each economy and changes in the price level. As such, it helps us to control for the tendency of U.S. FDI to concentrate in larger economies. It also allows us to control for changes in each of the economies under investigation that are not controlled by our set of independent variables.

We use the real (RER_t) rather than the nominal exchange rate (e_t), since uncertain price levels as well as exchange rates are relevant for long-term investments. All real exchange rates used are constructed from bilateral nominal exchange rates *vis-à-vis* the U.S. dollar and the ratio of prices in the U.S. relative to national prices (measured by the consumer price index (*CPI*)). We express these in logs:

$$RER_t = \ln\left[e_{t(mex/u.s)} \times \frac{CPI_t^{U.S.}}{CPI_t^{Mexico}} \right]$$

An increase in the real exchange rate index indicates a real appreciation of the U.S. dollar.

As control variables we include U.S. and domestic GDP growth, openness to trade, inflation and a dummy variable to account for changes in the exchange rate system. The GDP of the source and the host country are included to account for the relative wealth of both countries.[iv]

Previous studies have revealed that openness to trade can be an important determinant of FDI. This is true for companies that seek to shift labor-intensive assemblies to their foreign subsidiaries, import inputs and capital goods and then export finished products to other countries or back to the parent firm (Tuman and Emmert, 2003). Therefore we include a measure of openness in our estimation, constructed as the ratio of total trade (exports plus imports) by GDP. Likewise, inflation has been thought to be another important determinant for FDI. A high rate of inflation may serve as a signal of economic instability and of the host government's inability to maintain an appropriate monetary policy. Moreover, FDI might not take place in high inflation countries because it creates additional uncertainty regarding the net present value of long-term investments (Trevino and Mixon, 2004). In this paper, we use the log difference of the consumer price index to account for inflation. Finally, an exchange rate dummy variable is constructed following the classification of Levy-Yeyati and Sturzenegger (2005). It takes a value of one for times in which the exchange rate was classified as pegged to the U.S. dollar and zero otherwise.

C. METHODOLOGY AND ECONOMETRIC SPECIFICATION

The impact of exchange rates and exchange rate uncertainty on FDI is estimated using a fixed effects model. Through the use of a fixed effects model, we are able to control for unobserved time invariant characteristics of each country. Hausman and the F-test indicate that the fixed effect model is appropriate over simple pooling and relative to a random effects specification.

The model we estimate is:

$$FDI_{(mex,us),t} = f\left(GDP_{mex,t}, USGDP_t, RER_{mex,t}, Vol_{mex,t}, Z_{mex,t}\right) \quad (1)$$

where $FDI_{(mex,us),t}$ is a measure of investment activity to the host country (e.g. *Mexico*) from the source country (the U.S.), in year *t*. $GDP_{mex,\, t}$ and $USGDP_t$ represent economic growth for the host and source country. RER is the real exchange rate and $Vol_{mex,t}$ is the measure of uncertainty (volatility) in the exchange rate. In Equation (1) volatility ($Vol_{mex,t}$) assumes different forms in order to permit us an evaluation of the impact of different measures of exchange rate uncertainty. Finally, $Z_{mex,t}$ is a set of control variables that include openness to trade ($Openness$), inflation in the host country ($Inflation$) and a dummy variable ($DPeg$) for times in which the exchange rate is pegged to the U.S. dollar.

D. ESTIMATION RESULTS

The literature on exchange rates has identified several approaches for proxying and measuring exchange rate uncertainty. Initially most economic work simply used variability in the exchange rate to approximate uncertainty. It was assumed that unconditional measures of volatility, such as the variance or rolling variance of the exchange rate, contained the notion of uncertainty. On the other hand, as the econometric techniques and data availability (longer time spans and higher frequencies) become available, there have been attempts to better and more precisely extract the concept of uncertainty from time series data on exchange rates.

In this paper, we use three different approaches to proxy exchange rate uncertainty. First, we use the variance of the exchange rate returns (σ^2), an unconditional measure of volatility, a fairly standard approach in the literature. Unconditional measures of volatility include both expected and unexpected volatility (Goldberg and Kolstad, 1995). The conditional variance should be a better measure if the study of interest is related to the concept of uncertainty, because it captures unexpected volatility (Diebold and Nerlove; 1989, Bera and Higgins, 1993). Thus, our second set of results involves estimating a standard GARCH model to obtain a conditional measure of volatility (h_t). Lastly we use the CGARCH model to decompose conditional volatility into a permanent (q_t) and a transitory component (t_t) to test whether the nature of exchange rate uncertainty matters.

We report on the various specifications for equation (1) to ascertain how the alternative measures of foreign exchange risk factor using a cross-section fixed effects regression model estimated by generalized least squares (GLS). Throughout the estimations, we use cross-section GLS weights and coefficient standard errors that are robust to within cross-section residual correlation and heteroscedasticity. Given that we are working with countries of different sizes and characteristics, cross-section weights are given.[v]

The results of estimating the various models are presented in Table 1. We first estimate an equation omitting exchange risk (column 1) and then subsequently incorporate the various measures of exchange risk (columns 2 through 4). Overall we note that host country inflation and openness have no discernable impacts on FDI in all of the specifications. Host country GDP growth, on the other hand, is associated with reductions in FDI, an outcome that is consistent with the fact that FDI flows to countries that are relatively less wealthy when investments are of a vertical nature. Along these lines, FDI to Latin American countries seems to be, in general, resource seeking. In fact, natural resource seeking and manufacturing activities type of FDI has been very significant in the region over the last decade (ECLAC, 2004). The estimations also reveal that the coefficient on U.S. GDP growth is positive and significant indicating that increases in U.S. income coincide with increases in U.S. direct investment flows into Latin American countries, as we would expect.

It is also important to note the results for $DPeg$, a dummy variable intended to account for fixed exchange rate regime periods. This dummy assumes the value "1" during periods in which, according to the classification by Levy-Yeyati and Sturgenegger (2005), the country practiced a fixed exchange rate regime. The sign of $DPeg$ is positive and is significant at the 1% level in each save the final specification. This indicates that fixity of the host currency to the dollar facilitates incoming U.S. FDI. This result is in line with the findings by Benassy-Quere *et al*. (2001) for a panel of 46 developing countries and Goldberg and Klein (1999) for South East Asian countries. Also, Trevino and Mixon (2004) had claimed that FDI that flowed into Argentina was in part facilitated by their currency board (the convertibility law).[vi]

Of particular interest is the effect of exchange rate levels on FDI. We find it interesting that the level of the real exchange rate has no discernable impact on FDI. Whether the real exchange rate is more or less depreciated does not seem to influence the investment decision. This result holds in all of our specifications and is in contrast to others who have measured an impact. Perhaps our results differ due to the area of coverage, FDI into developing countries. Studies reporting a significant impact of the exchange rate level on flows use data for flows into the industrialized countries.

<<Table 1>>

***Unconditional Measures of Volatility*:** A main concern is with respect to the impact of exchange rate uncertainty on investment flows. The expected future exchange rate is a variable in the information set of investors because it influences the returns to investment. But investors are usually uncertain about the future value of the exchange rate. A standard approach in the literature has been to proxy uncertainty in the exchange rate (foreign exchange risk) by computing the unconditional variance of exchange rate returns. The unconditional variance is computed using a conventional variance formula (a time-invariant measure of the average of the squared deviation from the mean). In order to obtain a time series of volatility (a historical measure), the usual procedure has been to use a rolling variance (or rolling standard deviation) of the series with a pre-determined rolling window. In this study, our measure of unconditional volatility is obtained as the rolling variance of the squared currency returns using a 12-month window.

In column (2) of Table 1 we report the results using the unconditional measure of exchange rate volatility. The results indicate that the coefficient on volatility is negative, although not statistically significant. The sign is consistent with previous studies that have made use of this estimated measure. Moreover, the lack of significance has also been previously reported when using an unconditional measure of volatility (see Bailey and Tavlas, 1988; Campa, 1993; Benassy-Quere *et al.*, 2001).

As we indicated previously, there are concerns that such measures of volatility are not adequate if one desires to capture uncertainty. Carruth *et al*. (2000) documents that these types of measures tend to provide little additional explanation of aggregate investment. The main objection is that, even if the measure captures the total variability of the series, part of that total variability is predictable. Thus, a variable may be very volatile, but for an economic agent, it may be predictable and possible to forecast and hence not contribute toward exchange rate uncertainty. A second criticism of this measure is that the range of moving average (or rolling window) is specified in an ad-hoc manner by the researcher.

To overcome these two criticisms, economic research in this area has moved toward obtaining the variance of the unpredictable component of the series. This is obtained by first specifying a stochastic process for the series. By developing a (non-ad hoc) forecasting equation for the exchange rate (based on an information set). The forecasting equation is estimated to obtain the residuals, and the uncertainty measure is computed as the variance of the estimated residuals. The stochastic process that generates the predictable component can be specified as an ARMA(p,q) model. The above mentioned procedure requires modeling first the mean equation while the variance process is modeled ex-post.

More recently, the literature has shifted towards the use of ARCH and GARCH measures to model the concept of uncertainty. The ARCH/GARCH approach to estimating uncertainty is obtained on the basis of an estimated econometric model in which both the mean and variance equation are estimated jointly. It is often observed that this method would capture volatility in each period more accurately.

<u>Conditional Measures of Volatility: A Proxy to Uncertainty:</u> ARCH and GARCH models are presumed to capture risk in each period more accurately because these models do not give equal weight to correlated shocks nor to single large outliers. They also allow us to capture several characteristics or stylized facts of the data (e.g. thick tails for the unconditional distribution, time varying variance, volatility clustering and serially uncorrelated movements). The ARCH model, proposed by Engle (1982) and generalized (GARCH) by Bollerslev (1986), characterizes the distribution of the stochastic error ε_t conditional on the realized values of a set of variables that may include lagged values of the conditional variance.

We can consider a simple GARCH (p, q) process for y_t,

$$y_t = f(x_t;\ \beta) + e_t \qquad e_t/\psi_{t-1} \sim N(0,\ h_t^2), \tag{2}$$

$$h_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i}^2, \tag{3}$$

where $f(x_t;\ \beta)$ refers to the conditional mean, x_t is a vector of explanatory variables that may include lagged y_t's, β is a Mx1 vector of parameters, ψ_{t-1} is the information set that contains all the information available through time *t-1*, and e_t is the error term. The conditional errors have zero mean and time varying variance, h_t^2. The conditional variance follows a GARCH process as in (3).

In order to construct the GARCH measures of volatility, we first determine the stationarity of the series. We perform augmented Dickey Fuller (ADF), the Elliot, *et al*. (1996) GLS detrended Dickey–Fuller (DFGLS), and Kwiatkowski *et al*. (1992) (KPSS) tests for unit roots on the log of each country's monthly real exchange rate. Monthly data is used in order to make use of more observations over the time span analyzed in this study. Table A1 in the Appendix displays the results for each of the series and indicates that all the exchange rates used in this study have a unit root in levels whilst they are difference stationary.

The model for the mean of each series is specified as an ARIMA model with specification selected using traditional Box-Jenkins (1976) methodology. The ARIMA models for the mean of the series, together with the GARCH model for the conditional variance of the real exchange rate, are reported in Table A2 in the Appendix. To ensure stationarity of the dependant variable, each model is estimated on the first difference of the log of the exchange rate. In most cases a first-order model (GARCH(1,1)) is sufficient to adequately specify the conditional variance. Colombia and Venezuela are exceptions and they are estimated as ARCH(1).[vii] All GARCH parameters are positive and significant. For most countries, shocks to the conditional variance, quantified by the sum of α_1 and β_1, are positive and less than one with the exception of Brazil.[viii] As the Q – statistics in Table A2 show, autoregressive models of the first difference of real exchange rates produce white noise residuals. An examination of the Q^2 – statistics indicate that each estimated model produces a white noise series for the squared residual series. From these models we obtained the series of exchange rate uncertainty (h_t^2). The monthly measures are aggregated to produce quarterly series that further enter into the fixed effect model predicting FDI.

Column 3 of Table 1 contains the estimates of a conditional measure of exchange rate uncertainty (h_t^2) on FDI constructed via the baseline GARCH model. These estimation results are indicative of a negative and significant impact of uncertainty on FDI flows. Recall that the unconditional measure of uncertainty was unable to detect the negative impact and these results are in line with the results by Amuedo-Dorantes and Pozo (2001) and Brzozowski (2006) who also used conditional measures of uncertainty for different samples of countries. The significance of the results reveals the power of the GARCH model to capture significant results in the investment–uncertainty relationship.[ix]

This paper further explores how uncertainty impacts investment by considering whether the nature of uncertainty matters. There has been an interest in decomposing uncertainty into its temporary (or short-run) and its permanent (or long-run) component. We now focus on this decomposition.

Transitory vs. Permanent Uncertainty: CGARCH Model Specifications: Several arguments can be made for decomposing uncertainty into short- and long-run components to assess the importance of the nature of uncertainty (volatility) on investment. The short-run component may reflect transitory (or high frequency) shocks causing investors to either postpone or hasten the decision to invest. Moreover, its impact on investment may differ from that of long-run or permanent shocks to uncertainty as we describe below.

Goldberg and Kolstad (1995) use data for the 1978–1991 period to test the impact of short-term volatility on patterns of bilateral FDI. Their results, both theoretical and empirical, indicate that short-term exchange rate variability has a positive impact on FDI. Their arguments imply that under risk aversion producers will expand the share of investment resources located offshore on account of short-run volatility. On the other hand, Byrne and Davis (2005) argue that investment is not impacted by shifts in permanent volatility, while in the case of temporary volatility investment will decline. They claim that, in most cases, firms can better handle the permanent component of volatility as they can insure against this type of volatility. However, sporadic shocks – the source of temporary uncertainty – are usually not accounted for in the investment decision-making. Their empirical findings confirm this as they find that domestic investment in the G7 countries is affected by the short-run uncertainty and not by the permanent component.

Sung and Lapan (2000) argue that both the transitory and permanent components of uncertainty matter for FDI because of the presence of sunk costs. If sunk costs must be incurred to enter the market, transitory exchange rate movements may have a permanent effect. Baum *et al*. (2001) make the argument in terms of the firms' profits. They argue that firms do care about the source of volatility. They will base the investment decision on the effect of macroeconomic uncertainty on profit volatility. Hence, there is an unambiguous result that a rise in volatility of the permanent component will boost profit volatility (firms act to take advantage of related permanent shifts in the exchange rate) while a rise in temporary volatility will dampen it (as firms become more conservative under heightened uncertainty). Finally, Chadha and Sarno (2002) empirically show differential impact due to long- and short-run uncertainty in prices on aggregate investment. Specifically, they find that short-run uncertainty in the price level is more important in determining real activity than long- run uncertainty.

In general, the results are mixed but tend to favor the conclusion that temporary volatility will deter FDI. Then again, the question often encountered is, how to proxy both the permanent and temporary measures of uncertainty? Chadha and Sarno (2002) among others, have used a Kalman filter to obtain both temporary and permanent components. Other papers rely on deviations or exchange rate misalignments from an estimated long-run equilibrium exchange rate. A recent approach is an extension of the basic GARCH model, the components GARCH (CGARCH) model of Engle and Lee (1999).

The components GARCH model offers a method for decomposing conditional volatility into a time-varying trend (a permanent component) and deviations from that trend (the transitory component). The long memory behavior of the volatility process is described as the sum of two conventional models where one has nearly a unit root, and the other has a more rapid decay (see Engle and Lee, 1999).

The CGARCH model makes use of a GARCH specification model to decompose conditional volatility into a long-run time-varying trend component and a short-run transitory component (deviations from that trend). The main difference between a GARCH model and a CGARCH model is that in the GARCH model shocks decay towards the unconditional variance, while in a CGARCH specification, shocks to the transitory component revert to the trend.

Following Bollerslev (1986), the forecast of the conditional variance from a GARCH (1,1) specification converges to the constant unconditional variance σ^2, such that the GARCH (1,1) specification can be alternatively expressed as in Equation (4). The last two terms in the final expression have an expected value of zero, such that h_t^2 also converges to the unconditional variance.

$$\begin{aligned} h_t^2 &= (1-\alpha_1-\beta_1)\sigma^2 + \alpha_1\varepsilon_{t-1}^2 + \beta_1 h_{t-1}^2 \\ &= \sigma^2 + \alpha_1(\varepsilon_{t-1}^2 - \sigma^2) + \beta_1(h_{t-1}^2 - \sigma^2) \end{aligned} \tag{4}$$

Engle and Lee (1999) extend the model to allow for the possibility that volatility is not constant in the long run. Therefore, they propose replacing the constant unconditional variance (σ^2) with a time-varying permanent component (q_t) to represent long-run volatility as:

$$h_t^2 = q_t + \alpha_1(\varepsilon_{t-1}^2 - q_{t-1}) + \beta_1(h_{t-1}^2 - q_{t-1}) \tag{5}$$

$$q_t = \omega + \rho q_{t-1} + \phi(\varepsilon_{t-1}^2 - h_{t-1}^2) \tag{6}$$

where the permanent component (q_t) is a function of a constant (ω) and autoregressive root (ρ).[x] The forecasting error $(\varepsilon_t^2 - h_t^2)$ serves as the driving force for the time-dependent movement of the permanent component. It has zero expected value, by definition of the conditional variance. On the other hand, $(h_t^2 - q_t)$ defines the transitory component (t_t) of the conditional variance. The forecast of the transitory component $(h_{t+k}^2 - q_{t+k})$ eventually converges to zero as the forecasting horizon is extended. Thus, given that the forecasting horizon is large enough, there will be no difference between the conditional variance and the trend. This is the motivation for q_t being called the permanent component.

From the system specification, α_1 quantifies the initial impact of a shock to the transitory component and β_1 indicates the degree of memory in the transitory component. The sum of α_1 and β_1 provides a measure of transitory shock persistence. Similarly, the initial effect of a shock to the permanent component is given by ϕ, while the autoregressive root, ρ, measures the persistence. When $0 < \alpha_1 + \beta_1 < 1$, short run volatility converges to its mean of zero, while if $0 < \rho < 1$ the long-run component converges to its mean of $\alpha_0 /(1-\rho)$.

While the GARCH (1,1) model is covariance stationary if ($\alpha_1 + \beta_1 < 1$), the CGARCH model requires that $(\alpha_1 \ \beta_1)(1-\rho)+\rho < 1$, which is achieved if $\rho<1$ and $(\alpha_1 + \beta_1) < 1$. Thus, covariance stationarity of the conditional variance is achieved if the permanent component and the transitory component are both covariance stationary. The non-negativity condition is achieved so long q_t is non-negative over time.[xi]

Temporary volatility, in these investment equations, can be viewed as generating uncertainty about future exchange rates, which may relate in turn to short-term speculative pressures. On the other hand, permanent volatility characterizes periods of change in the exchange rate that stem from macroeconomic adjustments in economic fundamentals. It reflects long-memory behavior or persistent uncertainty. Table 2 contains the estimated CGARCH models for each of the exchange rates in monthly frequency.

<<Table 2>>

The conditional variance specification is estimated with most parameters significant and positive. Trend persistence is very high, at or over 0.8 for most countries' currencies. Transitory volatility is also high. Finally, residual diagnosis indicates that each estimated model produces white noise for the squared residual series.

To illustrate the difference among components, in Figure 1 we illustrate the conditional variance versus the permanent component and Figure 2 illustrates the transitory component. These Figures provide the basis for testing the effects of permanent and transitory volatility on investment. The permanent component approaches a moving average of the GARCH estimates, while the temporary component tracks much of the variations of the GARCH estimates.

<<Figure 1>>

<<Figure 2>>

We estimate the effect of both components of exchange rate uncertainty on FDI and report the results in the last column of Table 1. Our results indicate that the permanent (or long-run) component of exchange rate uncertainty has a negative impact on FDI, while the temporary component has no statistically significant impact. Hence our results differ from what has been found in the literature, thus far. While others claim to link temporary uncertainty to FDI (Goldberg and Kolstad, 1995; Sung and Lapan, 2000; Baum *et al*., 2001), in the case of Latin America, we find that it is the permanent component that matters. In fact, in light of the notion that FDI involves a long-term commitment and given the specific characteristics of Latin American countries, it makes sense that it is long-term uncertainty that is more detrimental to FDI.

We find it interesting that the dummy variable for pegged exchange rate regimes is no longer significant. This may indicate that by separating permanent from temporary uncertainty we are better accounting for uncertainty and therefore need not adjust for the exchange rate regime. In other words, it may be that in the earlier specifications the exchange regime dummy variable was proxying for some aspect of permanent uncertainty.

E. SUMMARY AND CONCLUDING REMARKS

Over the years, Latin American countries have instituted market friendly reforms in order to attract FDI, perhaps in response to growing evidence that FDI can accelerate economic growth (see Calderon and Schmidt-Hebbel, 2003 and Borensztein et al. 1998).[xii] In this context, identifying the determinants of FDI becomes not only an academic question but of interest for policy-making. In this paper, our goal was to investigate the impact of the foreign exchange market on U.S. direct investment flows into Latin America. To this end, we used data on U.S. direct investment into seven Latin American countries -- Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela -- for the 1994–2005 period. In addition to currency returns and other common control variables, we explore the role that exchange rate uncertainty plays in this process.

The results of this study have important economic policy implications. These seven economies receive over 85% of the total FDI flowing to Latin American countries. Moreover, the U.S. is the main source of FDI flows into Latin America (ECLAC, 2005). Changes in the patterns of U.S. investment into these countries can potentially bring about important changes to the region. Accordingly, accounting for determinants of FDI including the exchange rate and exchange rate uncertainty is of relevance.

Overall we find that discrete variations in the real exchange rate do not impact FDI. That is, countries do not need to manipulate exchange rate levels if their goal is to promote FDI inflows. A more or less depreciated real exchange rate does not seem to encourage or discourage FDI. On the other hand the level of real exchange rate uncertainty does matter, significantly impacting the level of FDI received. It appears that investors can deal with discrete changes in relative prices that arise through discrete exchange rate movements. But investors are less able to manage or they do not tolerate uncertainty in exchange rate movements. In particular, persistent uncertainty is found to deter FDI.

This finding is derived from an extensive inquiry into uncertainty's impact on FDI using a battery of measures to proxy exchange rate uncertainty. First, we used an unconditional measure of volatility. Such a measure is believed to capture total variability -- both predicted and unpredicted uncertainty. We also used conditional variances from GARCH and CGARCH models. The CGARCH estimation is of particular interest because it allows us to decompose uncertainty into temporary (short-run) and permanent (long-run) components. We find a negative effect of uncertainty across specifications indicating that U.S. investors are discouraged by exchange rate uncertainty. Moreover, it is the persistency in uncertainty rather than transitory uncertainty that mostly deters foreign investment.

The conclusions of this study therefore indicate that policies that better tame permanent uncertainty would be important to implement in the event that policymakers desire to promote increasing levels of inward FDI. Although it is impossible to completely eliminate uncertainty, the costs imposed by an uncertain exchange rate are measurable. Pursuing policies that increase the predictability of economic fundamentals can go a long way in making the climate more favorable for foreign investment.

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Table 1 – The Impact of Exchange Rate and Exchange Rate Uncertainty on FDI

Variable	(1)	(2)	(3)	(4)
Constant	0.0038 * (0.0018)	0.0039 ** (0.0018)	0.0035** (0.0019)	0.0039 * (0.001839)
Dummy Variable ($DPeg$)	0.0024 * (0.0007)	0.0022 * (0.0006)	0.0021* (0.0006)	0.0020 (0.0007)
Host country Growth	-4.1E-07 *** (2.4E-07)	-4.8E-07 *** (2.9E-07)	-5.6e-07** (2.8e-07)	-4.2E-07 (3.1E-07)
U.S. GDP Growth	7.8E-07 ** (3.4E-07)	7.3E-07 ** (3.3E-07)	7.1e-07** (3.4e-07)	7.8E-07 * (3.1E-07)
Inflation	-1.E-05 (1.7E-05)	-9.9E-06 (1.7E-05)	-8.5e-06 (1.7e-05)	-8.9E-06 (1.7E-05)
Openness	0.0031 (0.0044)	0.0063 (0.0066)	0.0157 (0.0103)	0.0108 (0.0090)
RER	1.4E-06 (6.2E-06)	1.4E-06 (6.3E-06)	1.5e-06 (6.2e-06)	8.8E-07 (6.1E-06)
σ^2	---	-0.0345 (0.0471)	---	---
GARCH (h_t)	---	---	-0.1216* (0.0461)	---
Temporary (t_t)	---	---	---	0.0724 (0.1256)
Permanent (q_t)	---	---	---	-0.0758 ** (0.0385)
F-test for Cross Section vs. Fixed Effect	50.42 *	42.44 *	40.38*	45.40 *
Hausmann Test (χ2(k-1))	12.19 **	11.76 ***	12.30***	11.74 ***
R-Squared	0.157	0.159	0.173	0.182
Adj. R-Squared	0.122	0.121	0.135	0.142
F-Statistic	4.481 *	4.179 *	4.612*	4.543

Note: *, ** and *** indicate significance at the 1%, 5% and 10% respectively. Standard errors are in parenthesis. Number of observations is 301 (7 countries). White cross-section standard errors and covariance (d.f. corrected).

Table 2 – Components GARCH Estimates for Real Exchange Rates.

	Permanent (ω)	Permanent $\rho = [q - \alpha_0]$	Permanent ARCH – GARCH [φ]	Transitory ARCH - q [α_1]	Transitory GARCH - q [β_1]	Q(12)	Q^2(12)
Argentina	-0.003 (0.006)	0.999 * (0.0015)	0.338 * (0.045)	-0.0364 (0.054)	0.655 * (0.211)	0.29	0.08
Brazil	0.0013 ** (0.0005)	0.898 * (0.134)	-0.0656 (0.265)	0.315 (0.267)	0.363 * (0.133)	7.36	0.75
Chile	0.0005 * (0.0001)	0.958 * (0.054)	0.074 ** (0.037)	-0.141* (0.042)	-0.344 * (0.368)	13.30	4.97
Colombia	0.0133 (0.208)	0.998 * (0.020)	0.0453 (0.203)	0.706 ** (0.413)	0.117 (0.148)	13.31	2.66
Mexico	0.009 (0.004)	0.995 * (0.017)	-0.025 (0.053)	0.057 (0.035)	0.851 * (0.089)	9.13	0.76
Peru	0.0006 * (2.96e-05)	0.938 * (0.022)	-0.128 (0.093)	0.118 (0.072)	0.761 * (0.070)	11.40	13.17
Venezuela	0.0001 *** (8.19e-05)	0.940 * (0.026)	0.052 (0.035)	0.508 * (0.077)	0.242 * (0.064)	5.85	2.99

Note: *, ** and *** indicate significance at the 1%, 5% and 10% respectively. Numbers in parenthesis are Bollerslev and Wooldridge (1992) robust standard errors. The mean equation is specified as an AR, MA or ARMA process. Q-statistic represents the Ljung-Box Q-statistic for the residuals, while Q^2-statistic represents the Ljung-Box Q-statistic for the squared residuals.

Figure 1 – Estimated Conditional Variance and Permanent Component of Chile

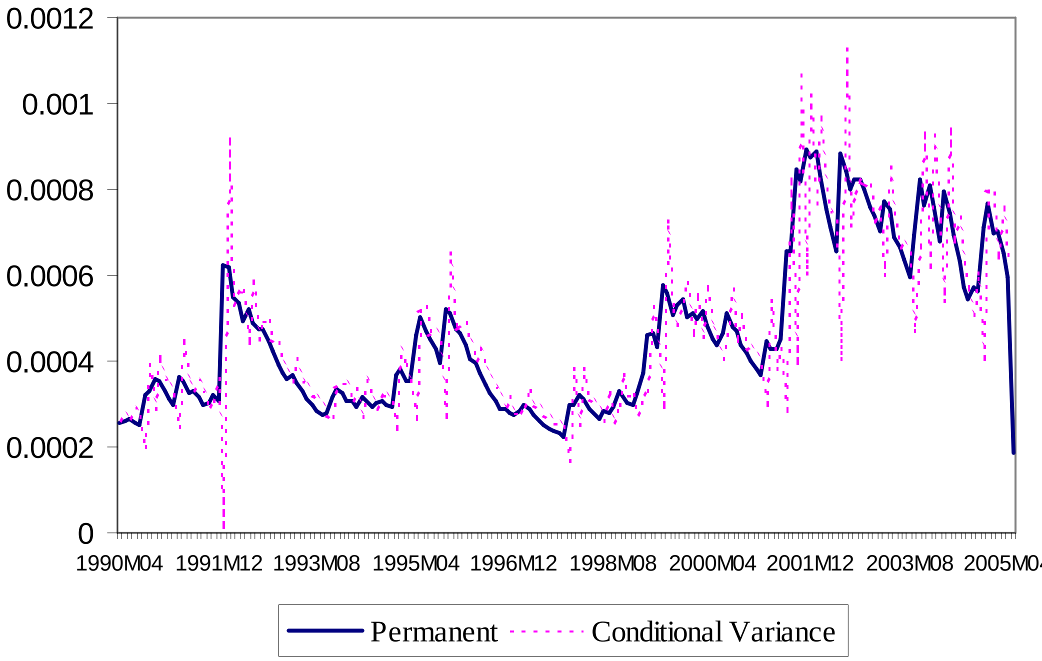
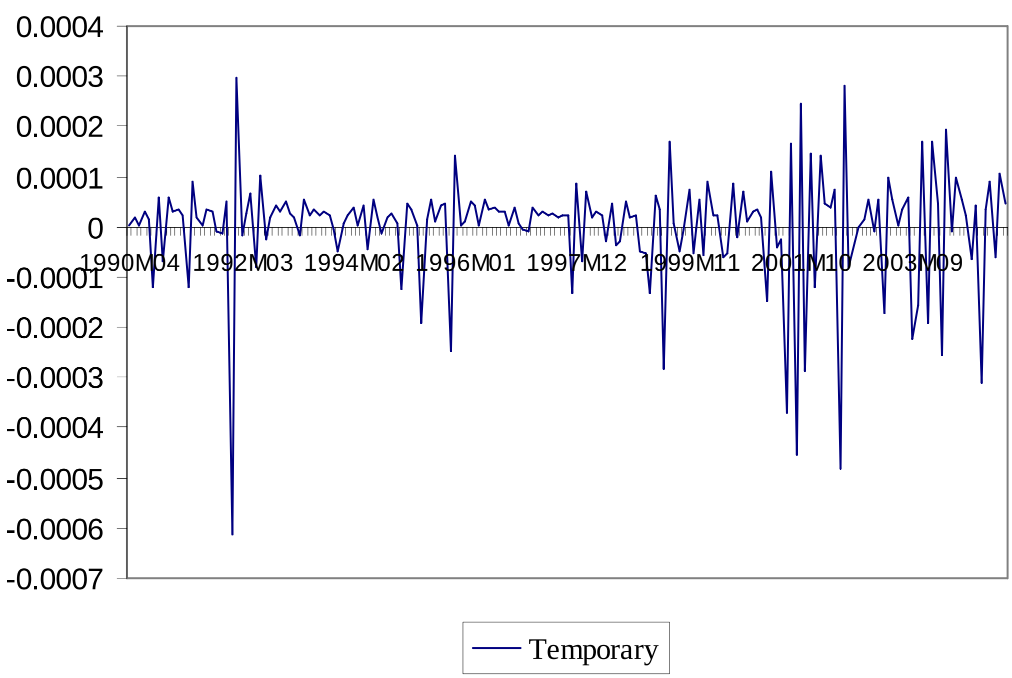


Figure 2 – Estimated Transitory Component of Chile



APPENDIX

Table A1 – Stationarity Properties of Monthly Log of Exchange Rates.

	ADF			DFGLS			KPSS	
	Trend	No-Trend	Diff	Trend	No-Trend	Diff	Trend	No-Trend
Argentina	-3.17 *	-1.62	-12.01 *	-1.05	-1.28	-2.55 **	0.35 *	0.77 *
Brazil	-1.43	-2.05	-12.63 *	-0.73	-2.04	-8.11 *	0.25 *	1.08 *
Chile	-1.98	-1.36	-10.91 *	-1.13	-1.23	-10.89 *	0.35 *	0.64 **
Colombia	-1.55	-1.55	-9.42 *	-1.05	-1.36	-9.43 *	0.35 *	0.36 *
Mexico	-2.45	-2.49	-8.36 *	-1.69	-2.39	-8.31 *	0.13 **	0.31**
Peru	-2.25	-3.87 **	-5.69 *	-1.40	-4.23 *	-5.47 *	0.90 *	0.19 **
Venezuela	-1.83	-1.69	-13.12 *	-0.80	-1.68	-1302 *	0.26 *	1.04 *

Note: *, ** and *** indicate significance at the 1%, 5% and 10% respectively. Critical values are obtained from McKinnon (1996). The null hypothesis of a unit root process is tested for the ADF and DFGLS tests. The KPSS tests the null hypothesis that the series is stationary. The number of lags is selected through the Schwartz Information Criteria (SIC).

Table A2 – Estimated G/ARCH Models of the Log Difference of Monthly Exchange Rates.

AR – G/ARCH Estimates									
	c	*AR (1)*	*AR (2)*	*MA(1)*	α_0	α_1	β_1	Q(12)	Q^2(12)
Argentina	0.001 (0.02)	-0.281 ** (0.129)	---	0.55 * (0.199)	0.0003 (0.0003)	0.298 (0.230)	0.544 * (0.134)	7.92	0.99
Brazil	0.003 (0.002)	0.419 * (0.075)	-0.149 ** (0.06)	---	0.0001 (8.41e-5)	0.358 * (0.130)	0.901* (0.07)	7.59	1.22
Chile	-0.007 (0.001)	0.241 * (0.073)	-0.114 (0.081)	---	2.57 e-05 (2.94e-.5)	0.075 ** (0.041)	0.872 * (0.091)	11.73	8.08
Colombia	-0.002 * (0.0009)	0.107 ** (0.047)	-0.073 ** (0.029)	---	9.21e-05 * (2.01e-05)	1.699 * (0.568)	---	8.50	7.20
Mexico	-0.0006 (0.002)	-0.0296 (0.093)	---	---	0.0003 (0.0003)	0.026 (0.060)	0.810 * (0.092)	14.21	1.94
Peru	-0.0005 (0.001)	0.340 * (0.087)	---	---	2e-05 *** (1.18e-05)	0.339 ** (0.132)	0.513 * (0.156)	11.60	7.99
Venezuela	-0.003 (0.002)	0.062 (0.079)	-0.108 * (0.035)	---	0.0005 ** (0.0002)	2.09 ** (0.978)	---	6.42	2.52

Note: *, ** and *** indicate 1%, 5% and 10% significance level. Bollerslev and Wooldridge (1992) robust standard errors are in parenthesis. We specify the mean equation as an AR, MA or ARMA process with serially uncorrelated residuals. Q- and Q^2-statistic represents the Ljung-Box Q-statistic for the residuals for the squared residuals.

DATA APPENDIX

Foreign Direct Investment (FDI)

FDI data for all countries is obtained from the Bureau of Economic Analysis (BEA) and the U.S. Department of Commerce. It comes from the statistics corresponding to U.S. Direct Investment Abroad: Balance of Payments and Direct Investment Position Data. This data accounts for the U.S. Capital outflows to foreign countries in quarterly basis.

Gross Domestic Product

Obtained from the IMF-International Financial Statistics CD-ROM. Codes of the IFS CDROM correspond to the lines following the B..ZF... category.

Nominal Exchange Rates

The nominal exchange rate is obtained from the IMF/IFS CD-ROM. It is defined as national currency per U.S. dollar. We used the official rate. Codes of the IFS CDROM correspond to the lines following the AF.ZF category.

Consumer Price Index

The consumer price index (CPI) for all Latin American countries is obtained from the IMF/IFS CD-ROM. It is an index corresponding to the definition of core prices as defined by each country (same base year). The CPI for the U.S. comes from the Federal Reserve Bank of Saint Louis (FRED). Codes of the IFS CDROM correspond to the lines following the ZF category.

Notes

[i] These seven economies account for over 85% of inward FDI into the region.

[ii] For a few exceptions with respect to Latin America, refer to Goldberg and Klein (1997) and Esquivel and Larrain (2002). While these studies explore how exchange rate changes affect FDI, they do not address the impact of exchange rate uncertainty on FDI.

[iii] Besides analyzing the channels through which exchange rates affect FDI, some studies have also suggested that not only the channel is relevant, but also the type of FDI flow (see Blonnigen, 1997).

[iv] We also included the SP500 as an alternative measure of U.S. wealth to test for robustness. Also, since FDI is most often thought to be a long-run investment; we proxied the cost of capital (the interest rate in the U.S.) with the Triple A 10- year bond rate. Neither of these variables added significant effects to the results so they are not included in the final results. All data, except the nominal exchange rate and the U.S. interest rates, are seasonally adjusted. See the appendix for additional detail on data procedures and sources.

[v] We further estimated all the regressions including lag uncertainty. The estimation results, not reported here but available from the authors, did not differ much from the results we present here.

[vi] Kiyota and Urata (2004), find that for Japanese investors, the U.S. dollar peg system has a mixed impact on FDI flowing to a sample of developing countries. They find that, for some industries, the impact of a pegged currency is negative while for others is positive.

[vii] Most empirical work finds that GARCH (1,1) adequately represents the conditional variance (see Bollerslev, Chou and Kroner, 1992). In cases where the GARCH (1,1) does not fit the series well, ARCH(1) is often adequate.

[viii] This result, although unusual, is sometimes the case for developing countries' exchange rates (see Speight and McMillan, 2001). We conducted a formal test of the null hypothesis of integration in variance for the Brazilian real on the basis of a Wald test of the restriction $\alpha_1 + \beta_1 = 1$. The null could not be rejected at the 1% level of significance. Integration in variance is often the result of structural breaks in the unconditional variance that produce a clustering of large and small deviations and is reflected in extreme GARCH persistence (see Speight and McMillan, 2001 and Lamoreaux and Lastrapes, 1990).

[ix] To explore the possibility of a nonlinear relationship, the squared terms of these uncertainty proxies were also used in the model. These results, not reported here, were almost identical to the reported results in Table 1.

[x] The original model defines the permanent component as a unit root process (ρ=1). However, Engle and Lee (1999) extend the model to a more general specification in which they allow the permanent component to be a non-unit root process.

[xi] See Engle and Lee (1999) for more detailed explanation of stationarity and non-negativity conditions.

Note that the component model reduces to the GARCH(1,1) if either $\alpha_1 = \beta_1 = 0, or \rho = \phi = 0$.

[xii] Calderon and Schmidt-Hebbel (2003) show evidence that portfolio equity and debt flows do not impact growth while FDI is the only major category of capital inflows that is relevant for long-term growth in Latin America. Furthermore, Borensztein *et al*. (1999) find that FDI flows into developing countries contributed to economic growth in a proportion greater than domestic investment.