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Does Real Exchange Rate Volatility Affect Foreign Direct Investment? Evidence from Four Developed Economies

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Does Real Exchange Rate Volatility Affect Foreign Direct Investment? Evidence from Four Developed Economies

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This study examines the impact of shocks to exchange rate uncertainty (volatility) on foreign direct investment (FDI) in Canada, Japan, the United Kingdom, and the United States. The analysis is conducted using vector autoregressive models that contain the price level, real output, the real exchange rate, the volatility of the real exchange rate, the interest rate, and FDI. The results from variance decompositions yield public policy implications. In Canada, Japan, and the United States, innovations to exchange rate uncertainty explain significant portions of the forecast error variance in FDI at longer time horizons. The impulse response functions indicate that, to the extent that shocks to exchange rate volatility have an impact on FDI, the impact is positive and takes place with a lag.

I. Introduction

The recent trend in globalization has led not only to increased trade but also to substantial increases in foreign direct investment (FDI) around the world. This has been facilitated by, among other things, the further liberalization of rules governing FDI through various WTO negotiations, as well as the transformation of the former centrally planned economies in central and eastern Europe and the Commonwealth of Independent States (CIS) towards market based policies. As international firms continue their search for more profitable overseas production facilities and markets, the growth in overall FDI is expected to increase further.

Recent fluctuations in the real exchange rate in developed countries have generated renewed interest in the impact of exchange rate volatility on the economy. A string of papers has analyzed the impact of exchange rate uncertainty on a number of macro variables including trade [Pattichis (2003) and Clark et al. (2004)], stock prices [Byrne and Davis (2003), Darby et al. (1999)), the price level (Cheong et al. (2005)].

In contrast, this article empirically analyzes the impact of exchange rate volatility (uncertainty) on the level of FDI in four of the G-7 countries, after controlling for conventional investment determinants. The countries included in the study are Canada, Japan, the United Kingdom, and the United States.[1]

Exchange rate fluctuations can complicate the investment decisions of international firms by making unpredictable the absolute and relative profitability in the traded versus the non-traded sector, as well as making uncertain the cost of new capital goods with high import content. The high degree of uncertainty of exchange rate movements during the last few decades has not only affected firms' decisions as to where to produce but has also affected their profits.

If changes in exchange rates affect only price movements, thus satisfying real purchasing power parity, then exchange rate movements would have very little effect. However, many studies [see Cashin and McDermott(2006),Guimaraes-Filho (1999), Pederson (2002), and Rogoff (1996)] and the references therein) have shown that purchasing power parity does not hold for all time periods. Hence, exchange rate volatility can affect the competitiveness of firms in different countries. In fact, it can potentially have a positive or a negative effect. On the one hand, firms are faced with the risk inherent in volatile exchange rates. On the other hand, firms have the opportunity to move production to take advantage of decreasing costs elsewhere [Cushman (1985), Goldberg and Kolstad (1995)].

A large number of empirical studies on the role of FDI in host countries suggest that FDI is an important source of capital, complements domestic private investment, is usually associated with new job opportunities and enhancement of technology transfer and boosts overall economic growth in host countries [see Chowdhury and Mavrotas (2006) and the references therein]. In view of the increasing need for additional foreign capital to achieve the Millenium Development Goals (MDGs) by the year 2015, FDI is now becoming quite crucial for many developing countries.[2] FDI has potentially desirable features that affect the quality of growth with significant implications for poverty reduction. It may reduce adverse shocks to the poor stemming from financial instability and help improve corporate governance. Furthermore, FDI generates revenues that may support the development of a safety net for the poor (Klein et al., 2001).

If we define FDI as a transfer of capital, it can be interpreted in terms of comparison of expected returns on alternative investment decisions. Hence, both the level and the variability of exchange rates can have an impact on the level of investment.

The level of the exchange rate affects FDI in a number of ways, depending on the destination of the goods produced. If the investor wants to produce for the local market, FDI and trade could be considered as substitutes. In that case, an appreciation of the local currency increases FDI inflows by increasing the purchasing power of local consumers. On the other hand, a depreciation in the real exchange rate of the recipient country increases FDI by reducing the cost of capital.

Esquivel and Larrain (2002) describe the two channels identified in the literature linking exchange rate volatility with FDI. First, potential investors will invest in a foreign country as long as the expected returns are high enough to cover currency risk. Thus, FDI will be lower when exchange rate volatility is higher. Second, changes in the bilateral exchange rates of the G-7 countries may directly affect the amount and direction of FDI through its impact on the real wealth in these countries. This may increase or decrease FDI depending on a number of factors including the change in the value of a particular currency, relevance of FDI as well as its wealth elasticity in the source countries.

The literature on both the theoretical and empirical effects of exchange rate volatility on FDI has come up with conflicting conclusions. The existing theoretical papers follow two different approaches. On the one hand, Aizenman (1992), Darby *et al.* (1999), and Sung and Lapan (2000) develop models based on the flexibility of long-run production.

While Aizenman (1992) develops conditions under which exchange rate volatility reduces FDI, the other two papers suggest a positive relationship between the two variables. On the other hand, a second string of papers put forward by Beenassy-Queeree et al. (2001), Cushman (1985, 1986) and Goldberg and Kolstad (1995) criticize the assumption of production flexibility and consider risk-aversion in the short-run with no possibility of adjusting the productive factors after the shock is realized.

On the empirical side, Froot and Stein (1991) have shown how, following the depreciation of the U.S. dollar in the post1985 period, foreign acquisition of U.S. firms increased. Moreover, given the imperfection in the capital market, a depreciating local currency increases the relative wealth of foreign firms and hence their capacity to invest in the United States. If, on the other hand, FDI aims at producing for re-export, it complements trade, and an appreciation of the local currency would lower FDI inflows by lowering competitiveness through higher labor costs.

However, in practice, it is difficult to differentiate among motivations of investors. A number of studies have shown that depreciation of the real exchange rate leads to higher FDI inflows (Ito et al., 1996; Goldberg and Klein, 1998). Appreciation, on the other hand, leads to a fall in FDI inflows (Cushman, 1988; Barrel and Pain, 1998). Klein and Rosengren (1994) have tried to differentiate between the wealth and labor costs channels for seven industrial countries investing in the U.S. during 1979--91. Their results indicate that only the wealth channel has played a significant role in investment decisions.

Variability in the exchange rate also affects FDI. Cushman (1988) has shown that, in the presence of exchange rate variability, producing in the destination market is a good substitute for exports. This holds as long as the production is not re-exported. Cushman finds a positive impact of exchange rate volatility on inward FDI. On the other hand, Esquivel and Larrain (2002) have shown that G-3 exchange rate volatility has a negative influence on FDI flows to sub-Saharan Africa. They go on to show that East Asia and the Pacific are not clearly affected by changes in G-3 currency volatility. The empirical evidence on FDI flows to Eastern Europe and South Asia is mixed.[3]

The above discussion shows that the impact of exchange rate uncertainty on the level of foreign investment is far from settled. Given that fluctuations in real exchange rates can lead to a higher level of uncertainty facing private investors, the actual magnitude of the effect can only be determined empirically. This constitutes the main objective of our article.

We use vector autoregressive (VAR) models to empirically examine the impact of exchange rate uncertainty (measured by the volatility of each country's real effective exchange rate) on FDI in Canada, Japan, the United Kingdom, and the United States. A separate VAR model is estimated for each country in our study. In addition to measures of FDI and exchange rate uncertainty, each model also contains the country's real output, price level, an interest rate, and the real effective exchange rate.

The uncertainty of each country's real effective exchange rate, as measured by the conditional volatility of the real effective exchange rate, is shown in Figures I—IV (to be discussed in detail shortly). As these figures show, there have been significant changes in fluctuation of real exchange rates in all four countries. This article analyzes whether or not the uncertainty in the exchange rate has an impact on the level of FDI in any of these four countries. This will also shed some light on how responsive each economy is to increased uncertainty in foreign variables.

II. Model Variables

The VAR model used for each country contains six(6) endogenous ariables. All data is taken from the OECD's Main Economic Indicators (MEI) CDRom. The main variable of interest is FDI. We use the balance of payments measure of direct investment in the reporting country as our FDI variable. To control for country size, we scale nominal FDI by nominal GDP.[4] That is, we divide nominal FDI by nominal GDP.

The general price level (P) in each country is thought to influence investment. For Canada, the United Kingdom, and the United States, we measure the price level with the GDP deflator. The MEI's data series on Japan's GDP deflator begins in 1994:1. In order to increase our estimation period to a reasonable size, we use the manufacturing producer price index as our measure of Japan's price level. Accelerator theories of investment posit that output is a major determinant of investment. Hence, we include real GDP (RGDP) in each country's model. For Japan, real GDP is defined as nominal GDP divided by the producer price index.[5]

Traditional theories of investment indicate that investment decisions depend, in part, on the long-term rate of interest. Hence, our models for Canada, the U.S., and the U.K. contain a long-term rate of interest (LR). We define the long-term interest rate as the ten-year government bond yield.[6] The MEI database does contain a long-term interest rate for Japan. However, the data on the long-term interest rate does not begin until 1989. In order to increase our estimation period to a reasonable size, our model for Japan contains a short-term interest rate (SR) instead of a long-term interest rate. SR is defined as the interest rate on Japanese 90 to 120-day certificates of deposit.

Each VAR also includes the MEI's measure of the real effective exchange rate (REX) and the volatility of the real exchange rate (H).[7] We use the conditional variance of the log of each country's real effective exchange rate as our measure of exchange rate volatility. With the exception of LR and SR, all data are seasonally adjusted.[8] P, RGDP, and REX enter the VAR models in logs. FDI is the ratio of nominal foreign direct investment to nominal GDP. LR (or SR) and H enter the models in levels. Quarterly data are used.

We restrict our estimation period to the post-Bretton Woods era. Hence, we do not use data prior to 1972:1 for any country in our study. The estimation period ends in 2005:3 for each country. For Canada, the United Kingdom, and the United States, data are available for the entire post-Bretton Woods period. After allowing for presample data for estimation of H and a maximum of eight (8) lags in the VAR, estimation of the Canada's VAR begins in 1975:2, estimation for the U.K VAR begins in 1974:3, while estimation of the U.S. VAR begins in 1975:1. Data on Japan's FDI begins in 1985:1. Hence, after allowing for a maximum of six (6) lags, estimation of Japan's VAR begins in 1986:3. Because data for Japan's REX exists prior to this date, we are able to construct the H series beginning in 1985:1.

III. Measuring Volatility

The conditional variance (H) of the real effective exchange rate is used to measure the volatility (uncertainty) associated with the real effective exchange rate (REX) for each country in our study. H is derived from a generalized autoregressive conditional heteroskedastic (GARCH) model. For purposes of comparison, we specify a GARCH (1,1) model in each case. The model for the mean of each series is specified with an ARIMA model. Each ARIMA model is selected using traditional Box-Jenkins(1976) methodology. The ARIMA model for the mean of each country's REX series, together with the GARCH model for the conditional variance of REX, are reported in Table 1.[9]

As the Q-statistics in Table I show, autoregressive models of the first difference of REX produce white noise residuals in each case. An examination of the Q^2-statistics in Table1indicate that, with the exception of Canada's REX, the GARCH(1,1) model produces a white noise series for the squared residual series.[10] As Table I shows, there are significant ARCH or GARCH effects in the REX for Canada, Japan, and the United States. At conventional levels of significance, both the ARCH and GARCH terms in the model for U.K. REX are insignificant.

A plot of H for each country in our study is shown in Figures I—IV. In each case we restrict the plot of H to the data used to estimate the corresponding VAR model. As these figures show, the conditional variance is not constant for any country in our study. Figure I shows that there is a particularly large increase in H near the end of our estimation period for Canada. Figure II shows that, for Japan, H spikes around 1987 and again around 1996 and 1999. Figure III reports the H for U.K. REX. An analysis of Figure III reveals that there is a major spike in the U.K.'s H around 1993. In general, the U.K.'s H is more stable in the later portion of our sample period than in the earlier portion. As reported in Figure IV, U.S. H is generally unstable for most of our sample period. U.S.H does become much more stable following 1999.

IV. Methodology

We employ a VAR model to examine the impact of a variety of macroeconomic influences on FDI.[11] Following Sims (1980), Fischer (1981), and many others, we examine the relationships among system variables by looking at the response of the system to "typical" shocks to system variables. A typical shock is defined as a positive one-standard-deviation shock to the residual from a given VAR equation.

One way to examine the impact on system variables of typical shocks is to compute variance decompositions (VDCs). VDCs show the portion of the forecast error variance of each variable in the system that is attributable to its own shocks and to shocks to other system variables. Both direct and indirect effects are captured by VDCs. In this paper we are most concerned with the portion of the forecast error variance in FDI explained by shocks to P, RGDP, REX, H, and LR.

VDCs can show if shocks to one variable have significant impacts on another variable. However, they do not show the direction of these impacts. We use impulse response functions (IRFs) to show the direction of these impacts. IRFs can be viewed as dynamic multipliers that give the current and subsequent effects on each system variable of an innovation (shock) to one of the system's variables. We are most concerned with the path taken by FDI in response to shocks associated with real exchange rate uncertainty (H).

As suggested by Spencer (1989), Akaike's Information Criteria (AIC) is used to determine the lag length for our VAR models.[12] Because data on FDI in Japan begins in 1985:1, the maximum lag length we consider is six quarters.[13] Our data for Canada, the U.K., and the United States begins in 1972:2. For these countries the maximum lag length considered is eight quarters. We do not apply the AIC blindly; we also examine the residuals from each VAR equation. Q-statistics are used to determine if the residuals from the various VAR equations are white noise.[14]

The AIC, together with Q-statistics, points to a lag length of six (6) quarters for the VAR models estimated for both the U.S. and Japan. The AIC and Q-statistics point to a lag length of four (4) quarters using Canadian data, while a lag length of two (2) quarters minimizes the AIC for the U.K.'s VAR model. Q-statistics indicate that each equation in each VAR model produces white noise residuals.

In order to compute VDCs and IRFs, the VAR residuals must be orthogonalized. We use a Choleski decomposition to produce these orthogonal residuals. The Choleski decomposition requires that the variables in the VAR be ordered in a particular fashion. Because of cross-equation residual correlation, when a variable higher in the ordering changes, all variables lower in the ordering are assumed to change.[15] The extent of the change depends of the degree of the residual correlation. Our results are based on the ordering P, RGDP, REX, H, LR, and FDI.

This ordering is consistent with the primary focus of our paper. FDI is placed last in the ordering. This allows shocks to all system variables to have a contemporaneous impact on FDI, but shocks to FDI have no contemporaneous impact on other system variables.[16] This is consistent with past investment studies in which current values of explanatory variables have an impact on investment. Based on the efficient markets arguments of Gordon and Veitch (1986), we place financial variables after P and RGDP in the ordering. That is, we place REX, H, and LR after P and RGDP in the ordering.

Based on the new Keynesian assumption that, in the short run, output is more flexible than prices, we place P prior to RGDP in the ordering. REX, H, and LR are all financial variables. However, REX is made up, in part, by the price levels in the domestic economy and its trading partners, and H is derived from REX. Because the price levels in these countries are likely to be sticky, at least in the short run, we place REX and H above LR in the ordering. This allows LR to respond contemporaneously to shocks to exchange rate variables. However, exchange rate variables do not respond contemporaneously to changes in LR. Finally, we place REX above H in the ordering. This allows REX, the mean of the exchange rate series, to have a contemporaneous impact on H, the conditional variance of the exchange rate series.

V. Empirical Results

The main results of the paper are contained in the VDCs and IRFs. The VDCs are reported in Table II, while the IRFs are reported in Figures V—VIII. Table II reports both point estimates and standard errors. The standard errors were derived using 5,000 bootstrap simulations. The estimates of the proportion of the forecast error variance are judged ‘‘significant’’ if the point estimate is at least twice as large as its standard error. VDCs at time horizons of 4, 8, 12, and 16 are reported to convey the dynamics of the system. Because the focus of our study is the determination of FDI, we report only the VDCs for FDI.

The VDCs for Canada are reported in the upper portion of Table II. An analysis of Table II reveals that, at longer time horizons, shocks to LR and H each explain significant portions of the forecast error variance in Canada's FDI. Aside from shocks to FDI itself, shocks to H and LR explain more of the forecast error variance in Canadian FDI than any other system variable at each time horizon. Hence, among the variables in our model, the long-term interest rate (LR) and exchange rate uncertainty (H) are the most important determinants of Canadian FDI. At the 16 quarter time horizon, shocks to H and LR each explain 12% of the forecast error variance in Canada's FDI.

Table II also reports the VDCs for Japanese FDI. An analysis of Table II reveals that, aside from shocks to FDI itself, only shocks to H explain a significant portion of the forecast error variance in Japanese FDI. Hence, among the variables in our system, only shocks to H have an impact on FDI. At longer time horizons, shocks to H explain morethan13%ofthe forecast error variance in Japan's FDI.

Table II also displays VDCs for U.K. FDI. As Table II shows, shocks to H explain at most 0.3% of the forecast of FDI in the U.K. This amount is never significant. Hence, H is not a determinant of FDI in the U.K. Further analysis of Table II reveals that FDI in the U.K. appears to be essentially exogenous. That is, only shocks to FDI itself explain a significant portion of the forecast error variance in FDI in the U.K.

The lower portion of Table II displays VDCs for U.S. FDI. Like the results for Japan, the results for the United State show that, aside from own shocks, only shocks to H have a significant impact on FDI. At time horizons 12 and 16, shocks H explain approximately 17% of the forecast error variance in U.S. FDI.

On balance, the VDC results in Table II show that H is the most important determinant of FDI in the countries in our study. No other system variable has a significant impact on FDI in the

U.K. The VDCs for Japan and the United States show that, aside from shocks to FDI itself, only shocks to H have a significant impact on FDI. In Canada, our VDCs indicate that, aside from own shocks, only shocks to H and LR have significant impacts on FDI.

The IRFs are reported in Figures V--VIII. Given the focus of our paper, we report only the IRFs for the response of FDI to H shocks. We have also calculated a two-standard deviation confidence interval for each IRF. A confidence interval containing zero indicates a lack of statistical significance. The confidence intervals were derived from 5,000 bootstrap simulations.

Figure V reports the IRF for the response of FDI to an H shock in Canada. An analysis of Figure V shows that a positive shock to H initially (time horizon 1) has a small, negative, and significant impact on Canadian FDI. The impact becomes insignificant for several time horizons, and then becomes significant at time horizon 10. The impact remains positive and significant during time horizons 10--13. The response is insignificant thereafter.

The results in Figures VI and VII indicate that H shocks have little, if any, impact on FDI in Japan and the U.K. Figure VI shows that a positive shock to H has an insignificant impact on Japan’s FDI at time horizons 1--5. The response becomes negative and significant at time horizon 6 and is insignificant thereafter. The results for the U.K., reported in Figure VII, indicate that a shock to H never produces a significant impact on FDI in the U.K. Like our VDC results for the U.K., our IRFs indicate that H shocks have no impact on FDI.

As Figure VIII shows, the response of U.S. FDI to an H shock is positive, and significant, at time horizons 2, 3, 7, 8, and 9.The impact of the H shock on U.S. FDI is insignificant in all other periods. Hence, increases in H lead to short-run increases in FDI in the United States. These increases take place with a one period lag.

On balance, the results in Figures V--VIII show that positive shocks to H tend to increase, or have no impact, on FDI. The impacts are generally positive in the United States and Canada. In Japan the impact of a shock to H on FDI is significant in one period only, while in the United Kingdom, the impact is never significant.

VI. Tests of Robustness: Error Correction Models

We have examined the dynamic relationships between FDI and its potential determinates using VDCs and IRFs derived from VAR models. In each of these models FDI is expressed as the ratio of FDI to output. Interest rates and the volatility of the exchange rate are expressed in levels. All other variables are expressed in log levels. We do this because, as Sims, Stock, and Watson (1990) point out, estimation of a VAR in levels is always appropriate.

Amudeo-Dorantes and Pozo (2001) suggest another way to examine the dynamic relationship between FDI and its determinates. Specifically, Amuedo-Dorantes and Pozo (2001) suggest estimating single-equation error correction models (ECMs). These models take the form,

(1) $\mathrm{FDI} = a_1 + a_2 P_t + a_3 \mathrm{RGDP}_t + a_4 \mathrm{REX}_t + a_4 H_t + a_5 \mathrm{LR}_t + u_t$

(2) $\Delta\mathrm{FDI} = b_1 + b_2 \Delta P_t + b_3 \Delta\mathrm{RGDP}_t + b_4 \Delta\mathrm{REX}_t + b_4 \Delta H_t + a_5 \Delta\mathrm{LR}_t + u_{t-1}$.[17]

Where Δ is the first different operator such that $\Delta\mathrm{FDI}_t = \mathrm{FDI}_t - \mathrm{FDI}_{t-1}$. As Amuedo-Dorantes and Pozo (2001, p. 338) note, the ''. . . u_{t-1} are the lagged OLS residuals from the estimation of the long-run relationship corresponding to the first step regression in the Engle-Granger (1987) two-step estimation procedure.'' Equation (1) is used as the estimated long-run relationship. Hence, u_{t-1} in equation (2) is the lagged residual from equation (1).

In addition to estimating the ECMs as specified in equations (1) and (2), we also estimate ECMs where P, RGDP, and LR are dropped from equations (1) and (2). Following Amuedo-Dorantes and Pozo (2001), in these equations we look at the impact on FDI of changes in REX and H without controlling for changes in other model variables.

The estimation results for ECMs for the countries in our study are reported in Table III.[18] All ECMs are estimated with OLS. An analysis of the results for our OLS estimates in Table III reveals many similarities with the results from VDCs and IRFs derived from our VAR models. First, in general, the REX is not significant in the FDI equations. That is, with the exception of Canada, the exchange rate itself is not a statistically significant explanatory variable. This is the case for both types of regression models. Second, H has a statistically significant, and negative, impact on FDI in Canada. Third, H does not have a significant impact on FDI in the U.K. Fourth, P and RGDP do not have significant impacts on FDI in any country in our study. Fifth, the interest rate (LR or SR) does not have significant impacts on FDI in Japan, the U.K., or the United States.

The results in Table III differ from our VDCs and IRFs in one important respect. Our VDCs and IRFs show that H has significant impacts on FDI in Japan. Our OLS results do not show this. It is not totally surprising that our single-equation (OLS) and VAR models produce different results in some cases. VAR estimation treats all model variables are as endogenous variables. The ECM's, estimated with OLS, treat other model variables as exogenous. Hence, a possible explanation for our conflicting results is that the OLS estimates suffer from a simultaneity bias. For example, if FDI has a causal influence on REX or H, the OLS estimates reported in Table III suffer from a simultaneity basis. In this case the coefficient estimates and t-statistics reported for the single-equation models in Table 3 will be biased, while our VAR models produce unbiased estimates.

Like Amuedo-Dorantes and Pozo(2001), some of our models in Table 3 regress FDI on

REX and H only. It seems clear that these models suffer from an omitted variables bias. For example, standard economic theory predicts that investment (FDI) is a function of Y and LR. Our VAR estimates do not suffer from omitted variables.

VII. Conclusion

We have examined the impact of shocks to macroeconomic variables on FDI in Canada, Japan, the United Kingdom, and the United States. Specifically, we have examined the impact of shocks to the price level, real output, the real exchange rate, the volatility of the real exchange rate, and the interest rate on FDI in these four countries. Our main interest lies in the impact of exchange rate uncertainty on FDI.

Our results have some important public policy implications. In Canada, Japan, and the United States, innovations to exchange rate uncertainty explain significant portions of the forecast error variance in FDI at longer time horizons.[19] Shocks to H appear to have the largest impact on FDI in the United States. In the U.S. shocks to H explain approximately 17% of the forecast error variance in FDI. In Canada shocks to H explain over 11% of the forecast error variance in FDI, while in Japan shocks to H explain over 13% of the forecast error variance in FDI.

Our IRFs indicate that, to the extent that shocks toHhave an impact on FDI, the impact is positive and takes place with a lag. The impacts are generally positive in the United States and Canada. The positive impact in the U.S. takes place with a one quarter lag. That is, there is a one quarter lag (delay) between the shock to H and the response of FDI. The positive impact in Canada takes place with nine quarter lag. Our IRFs for the U.K. never indicate a significant impact of H shocks on FDI. In Japan, H shocks have a significant, but small, impact on FDI in one period only.

Our IRFs point to some interesting public policy implications with regard to FDI and H. As we note above, in general, positive shocks to H have a positive impact on FDI in the countries in our study. That is, an increase in H will increase FDI, while a decrease in H will decrease FDI. This leaves us with an odd policy prescription. Increases in FDI can be obtained through increases in exchange rate volatility.

Our results clearly suggest the need for more individual country studies on the above relationship as it can be country-specific. At the same time, increased attention needs to be given to the overall role of exchange rate uncertainty as a crucial determinant of FDI along with the quality of human capital, infrastructure, institutions, governance, legal framework, ICT and tax systems in host countries.

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Notes

1. Our original intent was to study FDI in each of the G-7 countries. Available data on French FDI begins in 1995, while data on Italian FDI begins in 1988. German quarterly data on FDI is available beginning in 1971:1. However, because of German unification, consistent German data on other variables, such as GDP, begins in 1991:1. These starting dates for France, Italy, and Germany would make for unreasonably small sample periods, even without taking into account the major structural shift that accompanied the launch of the Euro on January 1, 1999.
2. See Nunnenkamp (2004) on this issue.
3. For a more detailed discussion of the literature on the impact of exchange rate volatility on FDI, see, among others, Amuedo-Dorantes and Pozo (2001), Kiyota and Urata (2002), Jeanneret (2005), Lee (2005), and Crowley and Lee (2005).
4. Note that scaling nominal foreign direct investment by nominal GDP produces the same variable as scaling real foreign direct investment by real GDP.
5. We have also estimated a VAR for Japan where the producer price index (PPI) is replaced with the consumer price index (CPI). Empirical results with respect to the impact of exchange rate volatility on Japanese FDI are unchanged if the price level is measured as the CPI rather than the PPI.
6. For Canada, the long-term rate of interest is the yield on 10-year government benchmark bonds. For the United Kingdom, the interest rate on 10-year central government securities is used as the long-term interest rate. The yield on 10-year federal government securities is the long-term interest rate used for the United States.
7. The real effective exchange rate is a chain-weighted index that takes into account the nominal exchange rate and the CPI’s of the thirty OECD member countries and sixteen other countries. The weighting takes into account relative market shares held by each country’s competitors.
8. The MEI contains P, RGDP, and nominal GDP in seasonally adjusted form. REX is reported in seasonally unadjusted form. Because REX is calculated, in part, with the CPI of various countries, it is likely that REX contains seasonal components. Foreign direct investment is also reported in seasonally unadjusted form only. We seasonally adjust foreign

direct investment and REX for each country using the X-11 procedure in SAS.

9. Because different ARIMA models are specified for the first difference of the real exchange rate (REX) in each country, the conditional variance of the real exchange rate (Ht) is estimated using a different number of observations for each country. A fourth order autoregressive model is specified for the first difference of Canada's REX. Hence, Canada's H_t is estimated using observations from the five previous periods. That is, one observation for differencing and four observations for the autoregressive model are used. A third order autoregressive model is specified for the first difference of Japan's REX and U.S. REX. Hence, Ht for Japan and the U.S. are estimated using observations from the four previous periods. Because a first order autoregressive model is estimated for the first difference of REX in the U.K., U.K. H_t is derived using observations from two previous periods.

10. Several alternative models were estimated for Canada's H. However, we were never able to obtain a white noise squared residual series for Canada's real exchange rate.

11. We have chosen to estimate our VAR in levels. FDI is defined as the ratio of foreign direct investment to GDP, while P, Y, and REX are expressed in logs. The interest rate (LR or SR) and H are not transformed. As Sims, Stock, and Watson (1990) point out, estimation of a VAR in levels is always appropriate.

12. Sawa (1978) has argued that the AIC tends to choose models of higher order than the true model. However, Sawa states that the bias is negligible when the selected lag length is less than (N/10), as it is here (N = number observations).

13. With six lags, each equation in the Japanese VAR is estimated with forty degrees of freedom. Expanding the maximum lag length to eight would leave only twenty-eight degrees of freedom.

14. Q-statistics are calculated using twelve lags.

15. Variables lower in the ordering are not allowed to *contemporaneously* influence variables higher in the ordering.

16. FDI does have an influence on other system variables through the lags in the VAR.

17. When data from Japan are used, LR is replaced by SR.

18. Each country's ECM is estimated over the same sample period as that country's VAR.

19. For the United Kingdom, shocks to exchange rate uncertainty never explain more than 0.3% of the forecast error variance in the FDI.

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Appendix

Figure 1: Volatility of Canadian Real Exchange Rate

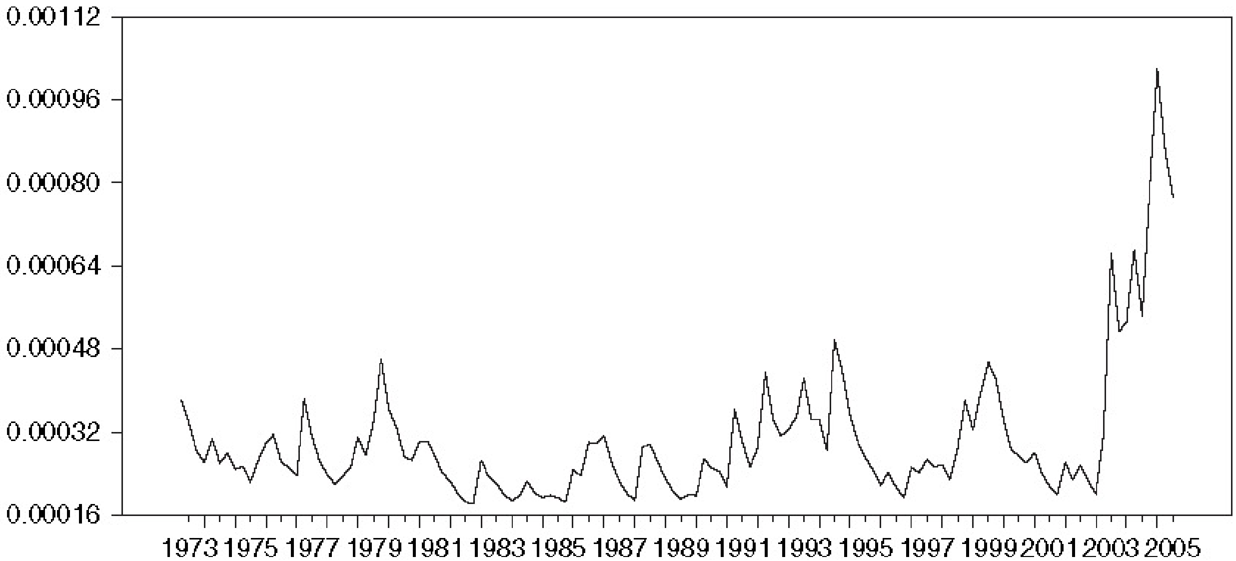

Figure 2: Volatility of Japanese Real Exchange Rate

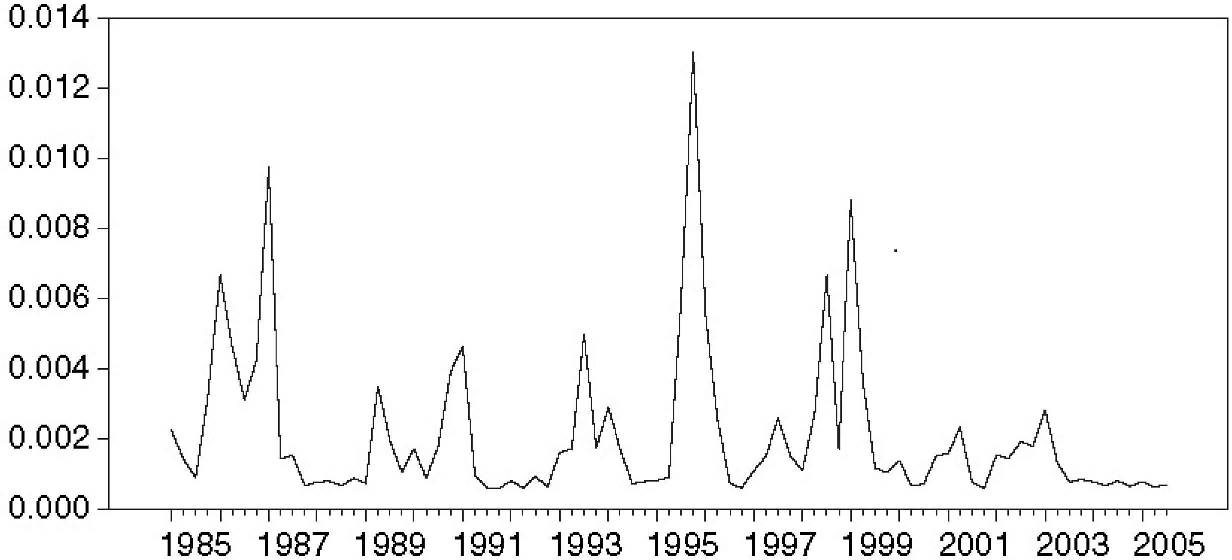

Figure 3: Volatility of United Kingdom Real Exchange Rate

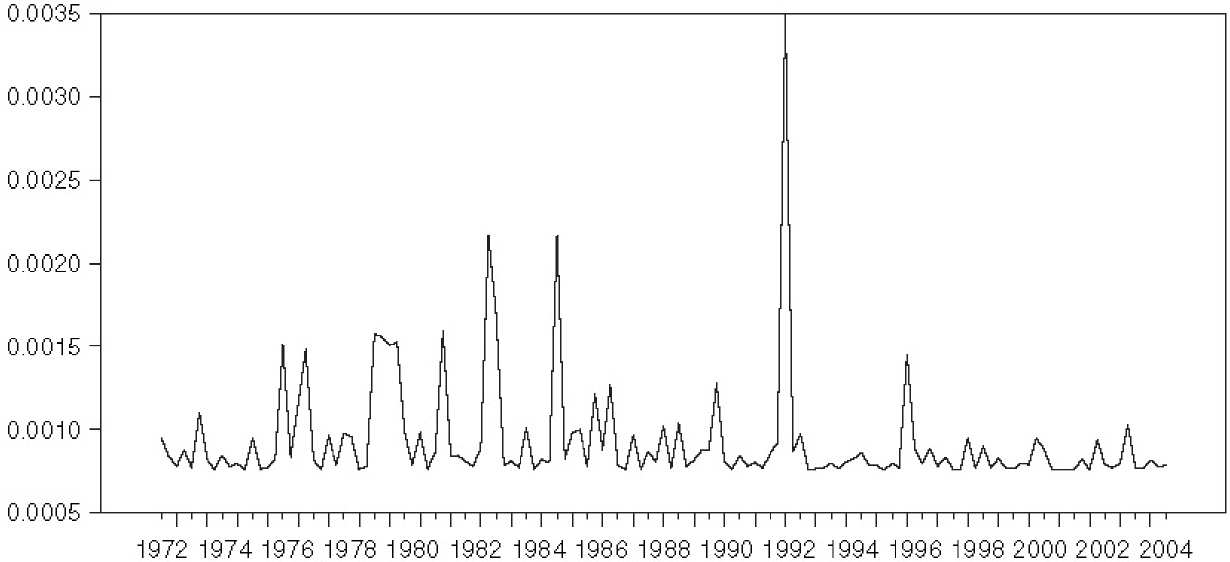

Figure 4: Volatility of United States Real Exchange Rate

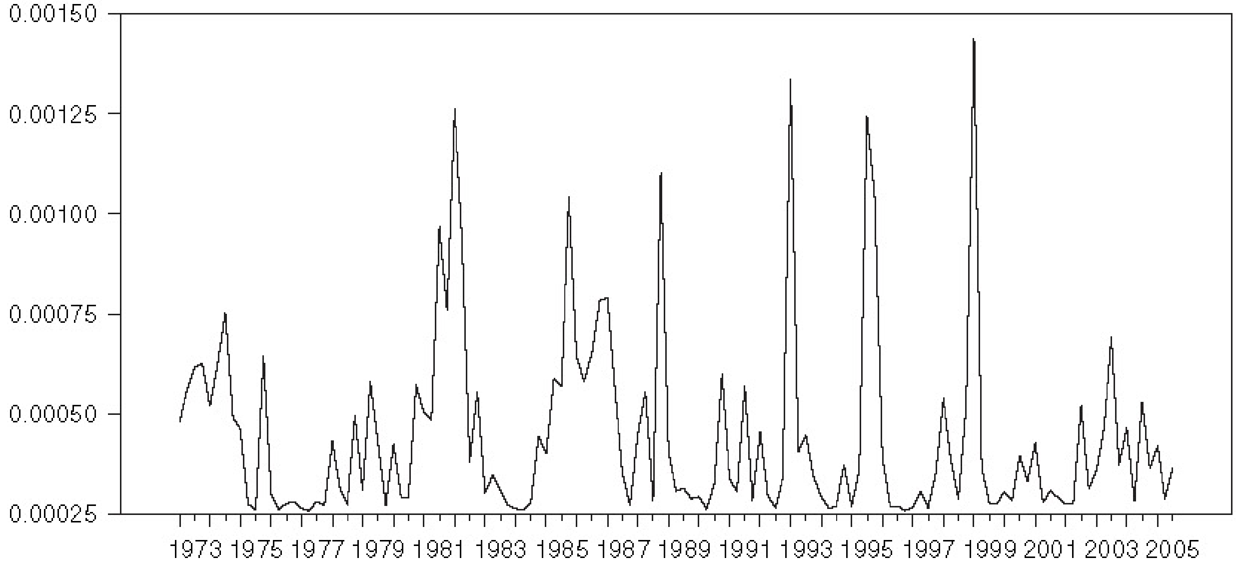

Figure 5: Response of Canadian FDI to H Shock

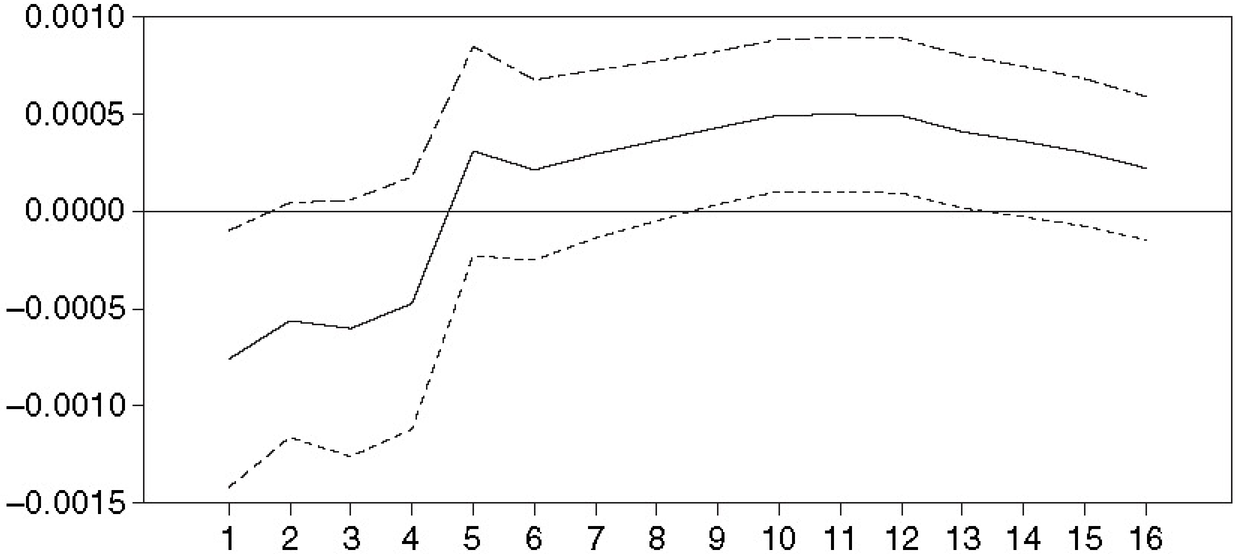

Figure 6: Response of Japanese FDI to H Shock

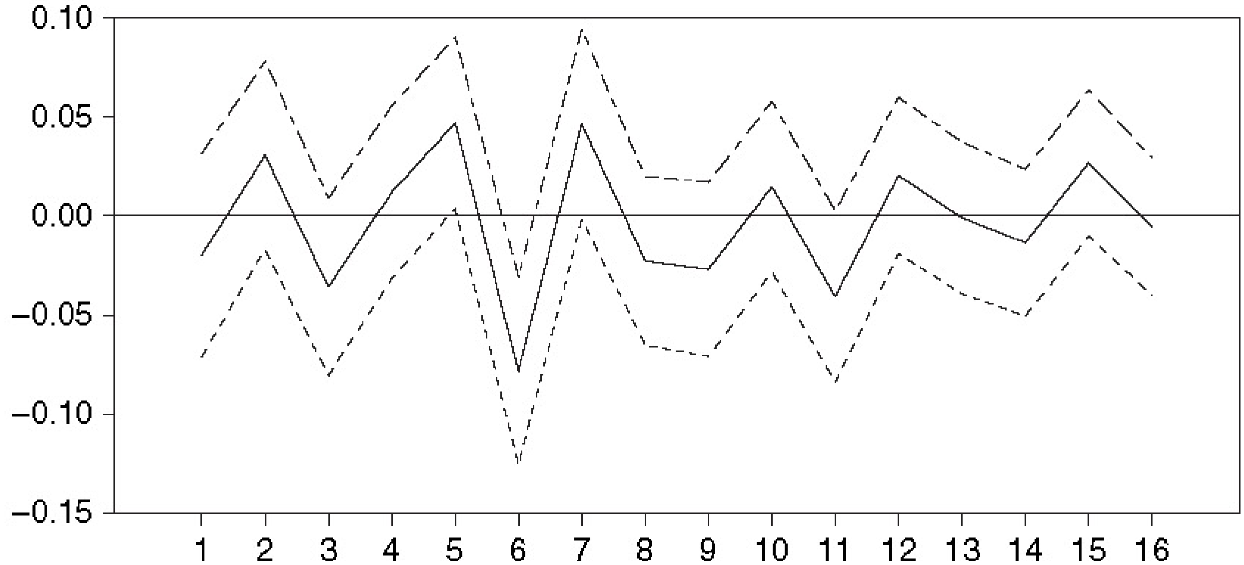

Figure 7: Response of United Kingdom FDI to H Shock

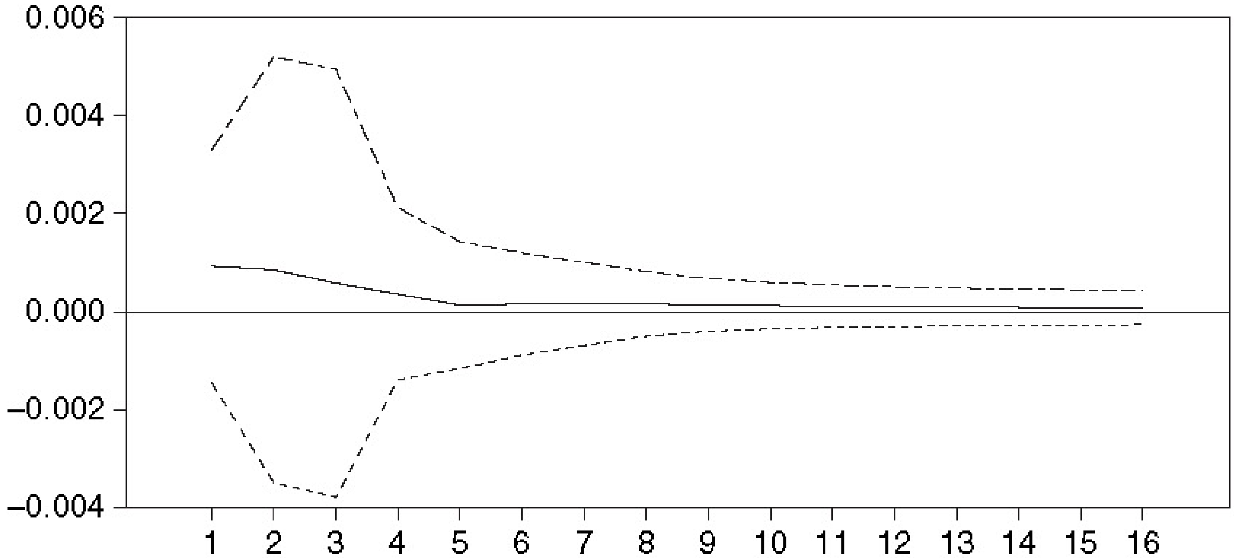

Figure 8: Response of United States FDI to H Shock

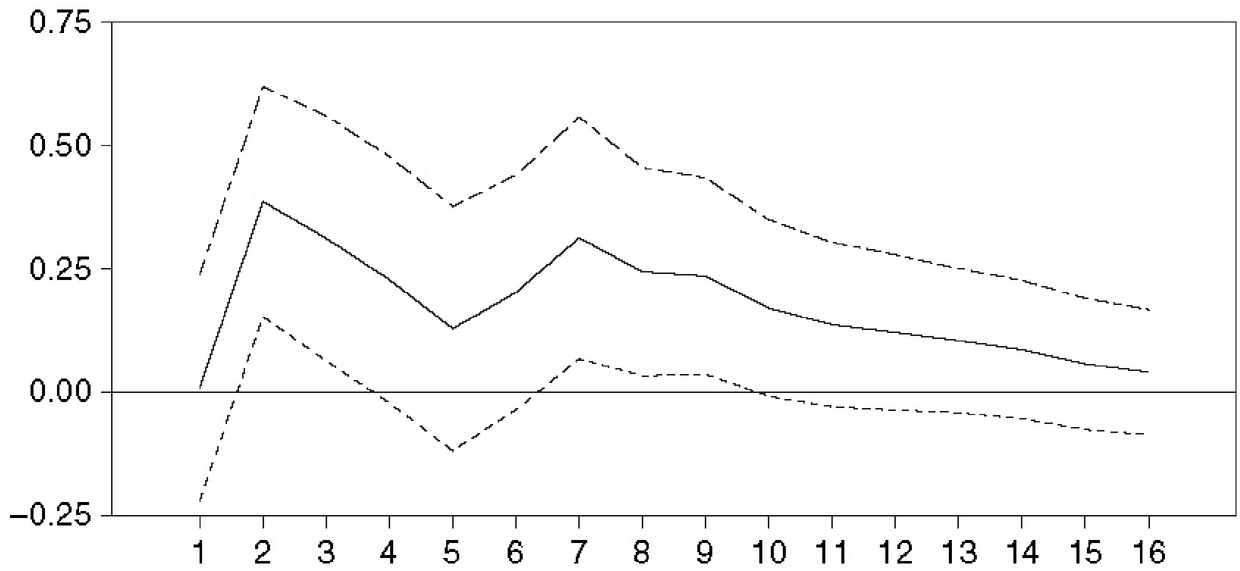

Table I: Real Exchange Rate Movement Forecasts and their Associated Volatility – H_t (absolute value of t-statistics in parentheses)

CANADA

$$(REX_t - REX_{t-1}) = \underset{(4.85)}{0.4584} (REX_{t-1} - REX_{t-2}) - \underset{(0.88)}{0.0863} (REX_{t-2} - REX_{t-3})$$

$$+ \underset{(3.67)}{.3089}(REX_{t-3} - REX_{t-4}) \underset{(2.62)}{-.2398} (REX_{t-4} - REX_{t-5}) + e_t$$

$$H_t = \underset{(1.04)}{0.00005} + \underset{(1.80)}{0.1716}e^2_{t-1} + \underset{(3.28)}{0.6838}H_{t-1}$$

Q-statistic(12) = 11.52, Q^2-statistic(12) = 57.04, Estimation Period: 1973:2 – 2005:3

JAPAN

$$(REX_t - REX_{t-1}) = \underset{(1.36)}{0.1442} (REX_{t-1} - REX_{t-2}) + \underset{(2.88)}{.2205} (REX_{t-3} - REX_{t-4}) + e_t$$

$$H_t = \underset{(2.31)}{0.0005} + \underset{(2.54)}{0.7527}e^2_{t-1} + \underset{(0.75)}{.0928}H_{t-1}$$

Q-statistic (12) = 15.33, Q^2-statistic (12) = 10.00, Estimation Period: 1985:1 – 2005:3

UNITED KINGDOM

$$(REX_t - REX_{t-1}) = \underset{(3.68)}{0.3652}(REX_{t-1} - REX_{t-2}) + e_t$$

$$H_t = \underset{(2.91)}{0.0007} + \underset{(1.23)}{0.1850}e^2_{t-1} + \underset{(0.10)}{.0234}H_{t-1}$$

Q-statistic(12) = 12.98, Q^2-statistic(12) = 7.87, Estimation Period: 1972:3 – 2005:3

UNITED STATES

$$(REX_t - REX_{t-1}) = \underset{(3.11)}{0.3031} (REX_{t-1} - REX_{t-2}) + \underset{(2.22)}{0.1704} (REX_{t-3} - REX_{t-4}) + e_t$$

$$H_t = \underset{(1.95)}{0.0002} + \underset{(2.15)}{0.3963}e^2_{t-1} + \underset{(0.29)}{.0801}H_{t-1}$$

Q-statistic (12) = 4.67, Q^2-statistic (12) = 17.47, Estimation Period: 1973:1 – 2005:3

Notes: Q-statistic is the Ljung-Box Q-statistic for the residuals, while Q^2-statistics is the Ljung-Box Q-statistic for the squared residuals.

Table II: Variance Decompositions of FDI

Relative variation in	Explained by innovations in					
CANADAIAN FDI						
Horizon	**P**	**RGDP**	**REX**	**H**	**LR**	**FDI**
4	1.0 (2.5)	1.7 (3.2)	2.2 (3.3)	7.3 (4.4)	6.8 (4.2)	81.0 (6.8)*
8	1.2 (2.6)	2.1 (3.5)	2.2 (3.3)	8.0 (4.5)	10.5 (5.1)*	76.0 (7.3)*
12	2.7 (3.0)	2.0 (3.4)	2.0 (3.3)	11.0 (5.5)*	11.8 (5.2)*	70.4 (7.9)*
16	3.7 (3.4)	2.0 (3.3)	2.0 (3.6)	12.0 (5.7)*	12.0 (5.2)*	68.3 (8.1)*
JAPANESE FDI						
Horizon	**P**	**RGDP**	**REX**	**H**	**SR**	**FDI**
4	9.4 (6.5)	9.1 (6.2)	3.5 (4.9)	3.6 (4.9)	3.9 (4.7)	70.4 (9.7)*
8	8.5 (5.5)	10.1 (5.6)	7.8 (5.4)	12.5 (6.6)	5.2 (4.5)	55.9 (9.0)*
12	8.2 (5.3)	11.3 (5.7)	9.4 (6.0)	13.5 (6.5)*	6.3 (4.4)	51.3 (8.7)*
16	9.4 (5.5)	11.0 (5.6)	10.9 (6.4)	13.4 (6.4)*	6.6 (4.3)	48.6 (8.6)*
UNITED KINGDOM FDI						
Horizon	**P**	**RGDP**	**REX**	**H**	**LR**	**FDI**
4	1.6 (2.2)	1.0 (2.0)	0.8 (2.3)	0.3 (2.3)	0.2 (1.8)	96.0 (5.1)*
8	1.7 (2.3)	1.3 (2.1)	1.4 (2.8)	0.3 (2.2)	0.2 (2.1)	95.0 (5.7)*
12	1.9 (2.4)	1.5 (2.2)	1.5 (2.9)	0.3 (2.2)	0.5 (2.3)	94.4 (5.9)*
16	2.1 (2.5)	1.5 (2.2)	1.5 (2.9)	0.3 (2.2)	0.8 (2.4)	93.8 (6.1)*
UNITED STATES FDI						
Horizon	**P**	**RGDP**	**REX**	**H**	**LR**	**FDI**
4	1.6 (3.3)	5.7 (5.1)	5.6 (4.7)	10.8 (6.2)	1.1 (2.4)	75.2 (8.6)*
8	1.7 (3.8)	10.7 (7.1)	4.5 (4.7)	14.6 (7.0)*	1.1 (2.4)	67.4 (9.2)*
12	2.4 (4.6)	10.7 (6.9)	4.4 (4.9)	16.9 (7.2)*	1.1 (2.4)	64.5 (9.2)*
16	3.3 (5.0)	10.6 (6.9)	4.7 (5.1)	17.1 (7.0)*	1.1 (2.3)	63.2 (9.2)*

Note: The entry in each cell represents the point estimate for the percentage of the forecast error variance in FDI explained by innovations to the indicated variable. Standard errors are in parenthesis. Point estimates are considered significant if they are twice as large as the standard error.

* indicates significance of the point estimate.

Table III: OLS Estimates of Error Correction Models Dependent Variable: ΔFDI Point Estimates (t-statistics)

Canadian FDI					
ΔP	**ΔRGDP**	**ΔREX**	**ΔH**	**ΔLR**	u_{t-1}
–	–	−0.034	−8.76	–	−0.76
		(−1.98)	(−2.33)		(−6.51)
F(3,118) = 24.88		Durbin-Watson statistic = 2.19			
0.02	0.04	−0.04	−12.35	−0.001	−0.87
(0.80)	(0.89)	(−2.33)	(−3.13)	(−1.30)	(−10.00)
F(6,115) = 15.20		Durbin-Watson statistic = 2.07			
Japanese FDI					
ΔP	**ΔRGDP**	**ΔREX**	**ΔH**	**ΔSR**	u_{t-1}
–	–	−1.07	−9.99	–	−1.01
		(−1.23)	(−0.44)		(−4.75)
F(6,70) = 21.02		Durbin-Watson statistic = 1.96			
2.88	−1.73	−0.88	−5.87	−0.20	−1.27
(0.39)	(−0.62)	(−1.10)	(−0.27)	(−1.83)	(−5.92)
F(3,73) = 25.40		Durbin-Watson statistic = 1.97			
United Kingdom FDI					
ΔP	**ΔRGDP**	**ΔREX**	**ΔH**	**ΔLR**	u_{t-1}
–	–	0.02	−3.00	–	−0.68
		(0.35)	(−1.49)		(−2.30)
F(3,121) = 12.92		Durbin-Watson statistic = 1.75			
−0.05	0.27	0.001	−0.115	0.0003	−0.80
(−0.38)	(1.43)	(0.03)	(−0.08)	(0.27)	(−2.87)
F(6,118) = 9.09		Durbin-Watson statistic = 1.71			
United States FDI					
ΔP	**ΔRGDP**	**ΔREX**	**ΔH**	**ΔLR**	u_{t-1}
–	–	4.85	−1915.99	–	−0.33
		(0.67)	(−1.52)		(−3.04)
F(3,119) = 13.15		Durbin-Watson statistic = 2.46			
−6.91	13.13	4.21	−1751.91	0.04	−0.48
(−0.30)	(0.85)	(0.63)	(−1.52)	(0.17)	(−4.84)
F(6,116) = 8.96		Durbin-Watson statistic = 2.30			

Notes: Each estimated equation contained a constant. Each estimated constant was small in size and statistically insignificant. Because of this, the constants are not reported in the table. T-statistics are derived with White (1980) standard errors.