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Asymmetric foreign exchange risk exposure: Evidence from U.S. multinational firms

Aline Muller, Willem F.C. Verschoor *

Nijmegen School of Management, Radboud University Nijmegen, Department of Economics, P.O. Box 9108, 6500 HK, Nijmegen, the Netherlands

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Abstract

This paper examines how U.S. multinational firms are affected by foreign currency movements. In light of detailed exchange rate data, we find that 29% of our sample of 935 U.S. firms with real operations in foreign countries is significantly affected by currency movements between 1990 and 2001. Results show moreover that U.S. stock returns react asymmetrically to currency movements. By introducing nonlinearity in foreign currency risk exposure, we noticeably increase the precision and the significance of exposure estimates. We demonstrate moreover that asymmetries are more pronounced towards large versus small currency fluctuations than over depreciation and appreciation cycles.

JEL classification: F3; G12
Keywords: Exchange risk; Asymmetry; U.S. multinational firms; Multinational-specific exchange risk factor

1. Introduction

Since the breakdown of the Bretton Woods system of fixed exchange rates, there is increasing interest in the volatility of exchange rates and its associated risks. It is now a widely-held belief that currency movements are a major source of macro-economic uncertainty that influence the profitability and value of multinational companies. Further, with the globalization of financial markets, the internationalization of trade and the recent currency crises, foreign currency exposure –

* Corresponding author. Tel.: +31 24 361 54 54; fax: +31 24 361 27 54.
E-mail address: w.verschoor@fm.ru.nl (W.F.C. Verschoor).

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defined as the sensitivity of firm value to exchange rate movements – has gained importance in business and international finance.

While analytical research consistently predicts the impact of exchange rate fluctuations on firm value (see e.g. Shapiro, 1975; Hodder, 1982; Adler and Dumas, 1984; Levi, 1994; Marston, 2001), empirical studies have not been able so far to give a clear answer on the real impact of foreign exchange rate risk. While in earlier years a consensus seemed to have emerged suggesting that exchange rate movements have no perceptible influence on stock returns (see e.g. Jorion, 1990; Bartov and Bodnar, 1994; Amihud, 1994), today, evidence in support of a significant impact of exchange rate movements on firm value (Dominguez and Tesar, 2006; Doidge et al., 2002; Dewenter et al., 2004) still confronts with inconclusive and puzzling results showing that this impact is weak and trivial (Griffin and Stulz, 2001). Interestingly, most of the studies assume that the impact of exchange rate fluctuations is symmetrical, and the sign and the size of the unexpected exchange rate shocks do not influence the resulting stock return reaction. According to Bartov and Bodnar (1994), this failure to account for the potentially asymmetric nature of currency risk exposure may explain the weak empirical findings.

There are numerous theoretical models focusing on trade flows, price formation, corporate behavior and investor sentiment showing that stock returns can be expected to respond asymmetrically to exchange rate shocks. Among them, (i) the asymmetric impact of hedging activities on cash-flows, (ii) firms' pricing-to-market strategies, (iii) their hysteretic behavior, (iv) investors' overreactions and mispricing errors, and (v) the existence of 'trigger points' at which external forces may intervene in the market are the most frequently cited arguments in favor of nonlinear currency risk exposures. While the asymmetric reaction of trade flows and prices has been empirically documented in prior literature (Baldwin and Krugman, 1989; Ohno, 1989; Knetter, 1994; Kanas, 1997; Pollard and Coughlin, 2003), the nonlinear response of stock returns to exchange rate movements has not received much attention in the exchange risk exposure literature until now. It should moreover be emphasized that the vast majority of empirical studies on nonlinear exchange risk exposure focus on the asymmetric nature of exchange risk exposure over appreciation–depreciation cycles (Choi and Prasad, 1995; Miller and Reuer, 1998; Baba and Fukao, 2000; Koutmos and Martin, 2003a; Koutmos and Knif, 2004; Tai, 2005; Priestley and Ødegaard, 2004). On the other hand, the possibility that firm value is differently affected by large versus small exchange rate fluctuations has only been analyzed by a few authors (Di Iorio and Faff, 2000; Williamson, 2001; Doidge et al., 2002; Bartram, 2004).

This paper makes several major contributions to the existing literature. First, it documents that the sensitivity of U.S. stock returns to exchange rate movements is asymmetrical as these asset returns respond differentially both to positive versus negative news from exchange rate markets and to large versus small currency shocks. In order to perform this firm-level analysis, we construct a new extensive data set consisting of 935 U.S. companies with real operations in foreign countries. The comparison of our result with previous U.S. evidence suggests that models assuming symmetric exposure are frequently misspecified and, thus, not able to detect the impact of currency movements on firm value. Finally, this study shows that the disaggregation of the worldwide trade-weighted U.S. dollar exchange rate index into six region-specific trade-weighted indices increases the precision and significance of exposure estimates.

The organization of the paper is as follows. Section 2 reviews theoretical work on the underlying reasons why firm value can be expected to be asymmetrically affected by exchange rate movements. In Section 3 the empirical methodology used to measure and test for asymmetric exposure is outlined. Data selection procedures and data sources are described in Section 4. The empirical findings follow in Section 5, with our concluding remarks in Section 6.

2. Asymmetries in exchange risk exposure

While most analytical papers on currency risk exposure predict a potentially nonlinear impact of exchange rate fluctuations on firm value (Shapiro, 1975; Hodder, 1982; Hekman, 1985; Booth and Rotenberg, 1990), the implicit assumption underlying the estimation of exchange risk exposure in the extensive empirical literature is – with few exceptions – that foreign currency exposure is linear.[1,2] The possibility that stock returns react asymmetrically to currency movements, and more specifically that the sensitivity of stock returns to changes in exchange rates may depend on the sign and magnitude of these changes, has received very little attention in the empirical literature until now. Yet, there are several reasons related to the behavior of both corporations and investors that may explain asymmetries in foreign currency exposure.

2.1. Asymmetries due to hedging activities

One major argumentation in favor of the asymmetry hypothesis is that companies may take asymmetric hedging strategies to control their foreign exchange exposures.[3] These hedging strategies may be financial or operational. Whereas forward and futures contracts eliminate both financial losses and gains if exchange rates move, currency options provide the downside protection while simultaneously allowing the upside potential. The asymmetric pay-off resulting from the use of these currency options has, thus, a non-linear impact on cash-flows and on firm value. Similarly, asymmetric responses to currency fluctuations may be observed when net exporters (net importers) decide to implement operational hedging strategies against domestic currency appreciations (depreciations) leaving depreciations (appreciations) unhedged.

The determination of the strike price(s) of currency option strategies is another argument supporting the non-linear response of stock returns to currency fluctuations. Indeed companies engaging in hedging activities choose currency options – hence corresponding strike prices and maturities – according to their needs and internal policies.[4] At the expiration date, the choice in terms of strike prices directly influences the impact of large versus small currency movements on the total pay-off of the strategy.[5] Following the same line of reasoning, operational hedging activities that are, for instance, exclusively implemented for large currency changes produce a similar non-linear impact on firm value.

To conclude, it is the very asymmetric nature of most financial and operational hedging strategies that explains why the impact of foreign exchange rate movements on stock returns may be different according to the sign and the magnitude of these movements.

[1] See, Adler and Dumas (1984), Jorion (1990), He and Ng (1998) for instance.

[2] For example if the empirical estimation of the currency risk exposure of firm i is 0.5, this means that if the currency appreciates/depreciates by 1% (10%), the stock return of firm i falls/rises by 0.5% (5%). Thus neither the direction, nor the magnitude of the currency movements will affect the sensitivity of firm i's returns to exchange rate fluctuations.

[3] If we assume that the objectives of corporate derivative usage are to reduce firms' foreign exchange risk exposure – and not to speculate – the question emerges whether these activities may constitute one possible explanation for the fact that empirical literature has found limited evidence of a significant link between exchange rate movements and firm value. This argument, which has first been supported by Bodnar and Gentry (1993) and Bartov and Bodnar (1994), has been empirically addressed in He and Ng (1998), Chow and Chen (1998), Simkins and Laux (1997), Allayannis and Ofek (2001) and Pantzalis et al. (2001).

[4] The more firms need downside protection, the more expensive the hedging strategy will be. Thus, a protection against exclusively extreme losses will be cheaper — and thus preferred by some companies. On the other hand, firms that expect currency movements to remain in a given range may choose not to hedge extreme exchange rate fluctuations.

[5] It has to be mentioned moreover that, generally, revenues from the sale of derivative products increase with currency volatility (Koutmos and Martin, 2003b).

2.2. Asymmetries due to asymmetric pricing-to-market behavior and resulting pass-through effects

Pricing-to-market behavior on behalf of companies has been quoted as a further potential reason for asymmetric stock price reactions to exchange rate movements (Froot and Klemperer, 1989; Knetter, 1994; Bodnar et al., 2002). Overall, the reaction to currency fluctuations depends on whether the firm pursues a market share objective or a profit-maximizing strategy. For instance, when the domestic currency depreciates, an exporting firm pursuing market share objectives maintains its export price in its currency and allows the export price in the foreign currency to fall. This enables the firm to gain market share when its currency depreciates. However, if the home currency appreciates, the exporter protects its market share by holding constant its foreign currency export price, rather than allowing it to increase. Subsequently, an appreciation of the domestic currency causes, in this case, a weaker pass-through effect than a depreciation. Similarly, an increase in substitutability between home-produced and foreign-produced goods – keeping market share objectives fixed – leads to weaker pass-through effects (Bodnar et al., 2002). On the other hand, an appreciation of the home currency may cause stronger pricing-to-market in the presence of trade volume or capacity constraints which will similarly result in asymmetric exposure (Marston, 1990; Knetter, 1994; Goldberg, 1995, Kanas, 1997). Thus, in some cases the pass-through associated with depreciations exceeds appreciations; however, in other cases this result is reversed. The resulting impact on firms' cash-flow is, in consequence, asymmetric. However, as suggested in Bodnar et al. (2002), the exact determination of the relationship is primarily an empirical issue since the strength of the pass-through effects depends on the elasticity of substitution between home-produced and foreign-produced goods, firms' market share objectives and their trade and production constraints.

Firms also respond asymmetrically to the size of the change in exchange rates. Because of the costs associated with changing prices, an exporting firm may, for instance, decide to allow its markup to absorb the effect of small changes in currency movements, which leads to a low pass-through effect. In contrast, large exchange rate fluctuations may force the exporter to deviate from his policy and pass-through part of the currency change into export prices. The fact that pass-through is generally positively related to the size of the change in exchange rates (Ohno, 1989; Pollard and Coughlin, 2003) shows that the impact of currency movements on firm cash-flows depends on the magnitude of these movements and tends to confirm the asymmetric currency exposure hypothesis.[6]

2.3. Asymmetries due to hysteretic behavior

The asymmetric impact of hysteretic behavior on firm value has been analyzed in earlier research on international trade (Baldwin, 1988; Baldwin and Krugman, 1989; Dixit, 1989). In the context of exchange risk exposure estimation, hysteretic behavior occurs, for instance, when exporters that have been attracted to new markets due to the depreciation of their home currency and the resulting asymmetric competitive advantage, remain in this "new" market once the domestic currency appreciates again. Hysteresis is, thus, closely related to the existence of high

[6] Pollard and Coughlin (2003) show even that the impact of exchange rate movements on pass-through depends more on the size of the currency change than on its direction.

market entry costs and more generally to the higher costs of reducing capital than increasing it — the so-called irreversibility of investment argument.[7]

As a consequence, the impact of a depreciation of the home currency on firm value is lowered for "new" entrants because of the high sunk-cost investments as well as for "old" exporters due to the increasingly competitive environment. On the contrary, the fact that both "old" and "new" exporters tend to remain in the market when the home currency appreciates – even if they suffer from operating losses – leads to a stronger negative impact on firm value. As a result, stock returns are expected to react asymmetrically to currency depreciations and appreciations.

It has nevertheless to be emphasized that referring to exchange rate exposure issues hysteretic behavior is strongly dependent on the magnitude of currency fluctuations. Baldwin and Krugman (1989) show for instance that in particular large exchange rate shocks may lead to entry or exit decisions that are not reversed when the currency returns to its previous level. On the other hand, small currency depreciations may not lead firms to extend their exporting activities to "new" markets, while sufficiently large appreciation swings in the domestic currency may induce many of the new entrants to leave the "new markets". The asymmetric impact of currency movements on firm value due to hysteresis is thus strongly dependent on the size of these exchange rate fluctuations.

2.4. Asymmetries due to investors' mispricing errors

Another argument supporting the asymmetric sensitivity of stock returns to currency movements is related to investor behavior. As highlighted in Bartov and Bodnar (1994), investors make systematic errors when characterizing the linkage between currency movements and firm value. These errors may arise because of the complex set of issues associated with (i) the identification of possible asymmetries in the impact of appreciations and depreciations, (ii) the determination of the extent to which a currency movement is temporary versus permanent, (iii) the estimation of the impact of the various changes in different foreign currencies for the overall economic performance and strategic behavior of the firm, and (iv) the evaluation of the impact of the firm's hedging activities on its sensitivity to exchange rate movements.[8]

Many arguments support the view that the relative importance of mispricing errors in the estimation of foreign currency exposure effects is dependent on the size and direction of exchange rate shocks. First, investors may find it difficult to assess the impact of small exchange rate movements on firm value. They, therefore, may have a tendency to assimilate these small fluctuations to random walk movements and to ignore their impact on firm value. Another argument in favor of asymmetric exchange risk exposure is related to investors' reaction to good versus bad news. There has been much research centered on the asymmetric impact of good and bad news on the mean and variance of stock returns (Bollerslev et al., 1992, 1995; Hentschel, 1995). The major findings concluded that investors are likely to react more to negative shocks (bad news) than towards positive shocks. Thus, we may expect that when valuing an exporting firm, for instance, investors consider a domestic currency appreciation as "bad" news which would result in a strong reaction (overreaction) in stock returns. On the other hand, domestic depreciations may not get as much consideration from investors. But, if the

[7] See for example Baldwin (1986, 1988) for a detailed discussion on hysteretic behavior.

[8] The fact that complex circumstances generally lead to systematic mispricing errors has been extensively documented in the literature. See e.g. Lakonishok and Vermaelen (1990) and Bartov (1992).

home depreciation gets large, the probability that investors pay attention to this favorable shock increases, leading to a positive valuation effect. It is, however, still possible that the positive news from the exchange rate market strengthens the future expected volatility – the volatility feedback effect – which in turn increases the required rate of return on the stock and, hence, lowers the stock price. This effect would, thus, dampen the positive impact of large favorable exchange rate shocks on firm value. In contrast, the increased expected volatility caused by large unfavorable currency movements might similarly increase the required rate of return and lower the stock price, amplifying the negative impact of "bad" exchange rate news.

2.5. Asymmetries due to so-called "trigger points"

A last line of reasoning corroborating the existence of asymmetric exchange rate exposure has been mentioned by Booth (1996). He argues that exposure changes over time with the magnitude of the currency shock and varies dramatically at "trigger points" where the nature of the market structure changes and with it the nature of firms' exposure. It may be, for instance, that at these "trigger points" governments intervene to assist industries that are suffering from a huge increase in imports or an erosion of export markets. As these interferences mostly occur in order to limit downside risks, the resulting impact on exchange rate exposure is asymmetric both regarding size and direction of currency changes.

In conclusion, it should be stressed that the extreme diversity of the numerous forces affecting the response of stock returns to exchange rate movements makes it terribly difficult to design an analytical model that fully accounts for all these different firm- and market-specific influences. The objective of this study is thus not to analytically predict the exact nature of foreign currency exposure but to empirically assess the asymmetrical properties of the relation between stock returns and exchange rate movements.

3. Methodology

The firm-specific exchange rate sensitivity, called *firm-specific exposure*, is defined as the effect of exchange rate changes on the value of a firm in excess of the global market's reaction to foreign exchange rate movements. Following Jorion (1990) and others, it is empirically estimated by the following model:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \gamma_i \theta_t + \varepsilon_{i,t} \tag{1}$$

where $R_{i,t}$ designates the total return of firm i in period t, $R_{m,t}$ the overall stock market return in period t, β_i firm i's return sensitivity to market fluctuations, θ_t the movement in a trade-weighted U.S. dollar world exchange rate index[9], γ_i firm i's exposure to the exchange rate index independent of the effect these currency movements have on the overall market, and $\varepsilon_{i,t}$ denotes the white noise error term. γ_i describes, hence, the sensitivity of stock returns to unanticipated changes in exchange rates.[10] Since the exchange rate index is measured as the

[9] The trade-weighted exchange rate index is defined as the price of one U.S. dollar in units of foreign currencies. An appreciation (depreciation) of the U.S. dollar will, thus, produce a positive (negative) value for θ_t.

[10] It is important to note that a zero γ_i coefficient does not imply that the firm is not affected by currency movements. It rather means that the firm value reacts to exchange rate movements to the same degree as the market portfolio.

price of one U.S. dollar in units of foreign currencies, a statistically significant positive γ_i coefficient implies that an appreciation of the domestic currency has a positive impact on a firm's stock returns — suggesting that the firm reacts like a net-importer or, more generally, that it has net short foreign currency positions, on average. By way of contrast, we expect to find for a net exporting company or a company with net long foreign currency positions a negative γ_i coefficient.

The implicit assumption made in the above-mentioned model (Eq. (1)) is the hypothesis of constant variance. This assumption is often rejected for common financial weekly time series — like exchange rate and stock return series.[11] As the presence of heteroskedasticity invalidates the test statistics of the ordinary least squares regression, we test whether the residuals $\varepsilon_{i,t}$ exhibit time-varying heteroskedasticity. We use the test Engle derived from the Lagrange multiplier principle to check the validity of the null hypothesis that the error terms of Eq. (1) $\varepsilon_{i,t}$ present no heteroskedasticity. If we do not reject the null hypothesis, we perform an ordinary least squares regression. Otherwise we add a GARCH(1,1) process to the initial augmented market model to incorporate conditional variance into the system (Bollerslev et al., 1992).[12] Thus, the regression model becomes:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \gamma_i \theta_t + \varepsilon_{i,t} \quad \text{with} \quad \varepsilon_{i,t} = \mu_{i,t} {}^{*} (h_{i,t})^{1/2} \qquad h_{i,t} = \delta + \tau_i \varepsilon_{i,t-1}^2 + v_i h_{i,t-1} \qquad (2)$$

where $h_{i,t}$ denotes the conditional variance of the residuals; δ_i, τ_i and v_i unknown parameters; and $\mu_{i,t}$ represents the white noise error term.[13]

The trade-weighted world exchange rate index enables us to capture the sensitivity of U.S. multinationals' stock returns to the fluctuations of a basket of foreign currencies consisting of currencies from all around world. As the index is based on trade-weights and currencies that do not always correspond to individual firms' trade patterns and cannot address the problem of low and negative correlations between some exchange rates, the use of a trade-weighted world exchange rate index is likely to understate currency risk exposures. Dominguez and Tesar (2001) show indeed in their empirical study that many firms are exposed to one or more bilateral rates included in the world exchange rate index but not to the index. Khoo (1994) and Ihrig (2001) provide similar evidence in support of the usage of firm-specific exchange risk factors.[14] To verify whether an imprecise specification of the exchange risk factor may have a significant impact on the empirical assessment of firms' currency exposure, we adopt the methodology suggested in Ihrig (2001) and decompose the currency risk factor in six different region-specific exchange rate indices.[15] As a result, we build for each company a *firm specific currency risk*

[11] See, for example, Bollerslev et al. (1992) and Nieuwland et al. (1994).

[12] The choice of a GARCH(1,1) specification is supported by many empirical studies which show that the GARCH(1,1) specification is valuable for modeling the variance generating process of financial time series.

[13] The unknown parameters are estimated by maximum-likelihood and generated using the Berndt et al. (1974) algorithm.

[14] These findings are however in contradiction with Bartram's (2004) and Fraser and Pantzalis' (2004) observations concluding that the use of a currency index versus individual, firm-specific bilateral rates does not mitigate the significance of exposure estimates.

[15] It should however be emphasized that in contrast to Ihrig (2001) who builds a firm-specific exchange rate index composed of bilateral exchange rates with the U.S. dollar of all countries in which the firm has subsidiaries, we build a *firm-specific* exchange rate index composed of *region-specific* currency indices of all *regions* in which the firm has real operations (*Directory of American Firms Operating in Foreign Countries*).

factor consisting of exchange rate indices of the regions in which the company has real operations. The model becomes thus:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \Gamma_i \Theta_t + \varepsilon_{i,t} \tag{3}$$

respectively:

$$\begin{aligned} &R_{i,t} = \alpha_i + \beta_i R_{m,t} + \Gamma_i \Theta_t + \varepsilon_{i,t} \\ &\text{with} \quad \varepsilon_{i,t} = \mu^*_{i,t} (h_{i,t})^{1/2} \qquad h_{i,t} = \delta_i + \tau_i \varepsilon^2_{i,t-1} + v_i h_{i,t-1} \end{aligned} \tag{4}$$

$$\begin{aligned} \text{where } \Gamma_i \Theta_t = {} & \gamma_{\mathrm{EU},i}\ \theta_{\mathrm{EU},t}{}^* D_{\mathrm{EU},i} + \gamma_{\mathrm{UK},i}\ \theta_{\mathrm{UK},t}{}^* D_{\mathrm{UK},i} + \gamma_{\mathrm{AS},i}\ \theta_{\mathrm{AS},t}{}^* D_{\mathrm{AS},i} \\ & + \gamma_{\mathrm{AU},i}\ \theta_{\mathrm{AU},t}{}^* D_{\mathrm{AU},i} + \gamma_{\mathrm{LA},i}\ \theta_{\mathrm{LA},t}{}^* D_{\mathrm{LA},i} + \gamma_{\mathrm{SA},i}\ \theta_{\mathrm{SA},t}{}^* D_{\mathrm{SA},i} \end{aligned} \tag{5}$$

$\theta_{\mathrm{EU},t}$, $\theta_{\mathrm{UK},t}$, $\theta_{\mathrm{AS},t}$, $\theta_{\mathrm{AU},t}$, $\theta_{\mathrm{LA},t}$, $\theta_{\mathrm{SA},t}$ denote the fluctuations of the price of one U.S. dollar in Euros, U.K. pounds, a basket of Asian currencies, Australian dollars, a basket of Latin American currencies and South African rands. $D_{\mathrm{EU},i}$, $D_{\mathrm{UK},i}$, $D_{\mathrm{AS},i}$, $D_{\mathrm{AU},i}$, $D_{\mathrm{LA},i}$, $D_{\mathrm{SA},i}$ describe the presence of firm i's real activities in Europe, the U.K., Asia, Australia, Latin America and South Africa. Depending on the presence or not of firm i's real activities in region j, the dummy variable $D_{j,i}$ takes the value of 1 or 0. Finally, $\gamma_{\mathrm{EU},i}$, $\gamma_{\mathrm{UK},i}$, $\gamma_{\mathrm{AS},i}$, $\gamma_{\mathrm{AU},i}$, $\gamma_{\mathrm{LA},i}$, $\gamma_{\mathrm{SA},i}$ measure the firm i's exchange risk exposure towards the euro, the U.K. pound, Asian currencies, the Australian dollar, Latin American currencies and the South African rand.

As described in Section 2, there are valid reasons to expect that stock returns respond asymmetrically to currency appreciations and depreciations. To test the asymmetry hypothesis we extend the standard augmented market model following Koutmos and Martin (2003a). Under the present circumstances this means adding a dummy variable S_t to model (Eqs. (3) and (4)):

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + (\Gamma_i + \Gamma_i{}'^* S_t)^* \Theta_t + \varepsilon_{i,t} \tag{6}$$

respectively:

$$\begin{aligned} &R_{i,t} = \alpha_i + \beta_i R_{m,t} + (\Gamma_i + \Gamma_i{}'^* S_t)^* \Theta_t + \varepsilon_{i,t} \\ &\text{with} \quad \varepsilon_{i,t} = \mu_{i,t}{}^* (h_{i,t})^{1/2} \qquad h_{i,t} = \delta_i + \tau_i \varepsilon^2_{i,t-1} + v_i\ h_{i,t-1} \end{aligned} \tag{7}$$

where S_t equals 1 when the exchange rate movement is negative and 0 otherwise. The parameters Γ'_i measure, hence, the asymmetric response of firm i's stock returns to negative exchange rate shocks. As suggested in Koutmos and Martin (2003a) we calculate the degree of asymmetric response of stock returns to exchange rate changes by taking the ratio $(\Gamma_i + \Gamma'_i)/\Gamma_i$.

For the estimation of the asymmetric response of stock returns towards large versus small currency fluctuations, we use logistic smooth transition regressions (Granger and Teräsvirta, 1993; Teräsvirta, 1998). The models presume that there are two regimes and that the transition from one regime to the other – triggered by the magnitude of the currency fluctuations – is a locally linear one. The two regime model is specified as:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + (\Gamma_i + \Gamma_i{}'^* F_i(u_t;\ k_i, \lambda_i))^* \Theta_t + \varepsilon_{i,t} \tag{8}$$

respectively:

$$\begin{aligned} &R_{i,t} = \alpha_i + \beta_i R_{m,t} + (\Gamma_i + \Gamma_i{}'^* F_i(u_t;\ k_i, \lambda_i))^* \Theta_t + \varepsilon_{i,t} \\ &\text{with} \quad \varepsilon_{i,t} = \mu_{i,t}{}^* (h_{i,t})^{1/2} \qquad h_{i,t} = \delta_i + \tau_i \varepsilon^2_{i,t-1} + v_i h_{i,t-1} \end{aligned} \tag{9}$$

Firm i's transition function F_i (u_t; k_i, λ_i) is bounded between 0 and 1 and depends on the magnitude of the exchange rate movement u_t defined as the squared currency movement[16] in week t:

$$F_i(u_t;\ k_i,\ \lambda_i) = (1 + \exp(-(u_t - k_i{}^* \,\bar{\mathrm{u}}_t)^* \lambda_i))^{-1} \tag{10}$$

where $\bar{\mathrm{u}}_t$ denotes the mean value of the squared foreign currency movements across the entire sample period. k_i locates, for firm i, where the transitions occur between the two regimes and λ_i indicates, for firm i, how rapidly the transition from one regime to another takes place.

Estimation of the parameters of the two-regime model is performed by ordinary least-squares (Eq. (8)) or a maximum-likelihood method (Eq. (9)). To alleviate the problems arising from predetermining k_i and λ_i, we determine the location parameter k_i and the adjustment speed λ_i using the Akaike information criteria (AIC).

4. Sample selection

4.1. U.S. multinationals

It is possible that the weak evidence of a contemporaneous link between exchange rates and U.S. stock returns in the existing empirical literature is caused by the data selection procedure (Bartov and Bodnar, 1994). As real foreign trade and production activities are important transmission channels of exchange rate shocks (Caramazza et al., 2004), we thus decide to focus our empirical study on the impact of currency fluctuations on U.S. multinational firms with real production and/or trade operations in foreign countries.[17,18] To identify these firms we follow a careful selection procedure consisting of four steps. The initial sample incorporates all U.S. companies that are registered in the 15th edition of the *Directory of American Firms Operating in Foreign Countries*. As we only include listed firms in our study, we check the firms for their weekly stock market return availability in the *University of Chicago Center for Research in Security Prices (CRSP)* database. Subsequently, we exclude firms that had not at least two years of consecutive weekly returns across the entire sample period from January 1990 to December 2001. This procedure yields a total sample size of 935 firms. Finally, all these firms are classified according to their four-digit SIC codes and their foreign operations are grouped in six geographical regions: Europe, U.K., Asia, Australia, Latin America and Africa.

In Table 1, we present the distribution of the sample firms across industry sectors and provide information about the geographical dispersion of their foreign trade and/or production activities.

[16] As a first set of sensitivity tests, we redefine the magnitude of the exchange rate movement u_t as the squared of the residual σ_t in week t of the following GARCH(1,1) model:

$$X_t = X_{t-1} + \Theta_t \quad \text{with} \quad \theta_t = \sigma_t{}^*(v_t)^{1/2} \quad v_t = \varphi + \kappa\theta_{t-1}^2 + \lambda v_{t-1}$$

where v_t denotes the conditional variance of the residuals; φ, κ and λ unknown parameters; and σ_t represents the white noise error term. Results – available from the authors upon request – show that redefining this variable has no significant impact on the coefficient estimates and conclusions that are central to this paper.

[17] To the extent that firms within a given industry portfolio are not uniformly involved in international trading activities, do not present identical financial and operational characteristics and do not engage in similar hedging strategies, they are not uniformly exposed to currency fluctuations. The aggregation of these different characteristics in industry portfolios leads therefore to a strongly reduced impact of exchange rate movements on industry portfolio returns.

[18] While empirical studies in the foreign exchange risk exposure literature typically focus on multinational companies (e.g. Jorion, 1990; Amihud, 1994; Choi and Prasad, 1995; He and Ng, 1998), Doukas et al. (1999) emphasize the need to be aware of the fact that pre-selecting a subset of assets according to prior assumptions of the main factors affecting exposure may introduce a bias.

It is interesting to note that the major international trading activities of U.S. multinationals included in our sample are located in Europe, U.K. and Asia.

4.2. Economic factors

This study uses two types of economic risk factors: the market risk factor and the exchange rate risk factors. The proxy for the market portfolio used is the CRSP value-weighted – respectively equally-weighted – U.S. market index as provided by the *University of Chicago Center for Research in Security Prices (CRSP)* database.[19,20] The exchange rate risk factors are measured as the continuously compounded rates of change in a worldwide trade-weighted U.S. dollar exchange rate index and in region-specific trade-weighted exchange rate indices.[21] The latest translate the evolution of one or more foreign currencies of the same geographical region towards the U.S. dollar. They are computed as a weighted average of bilateral exchange rates[22] according to the following formula:

$$X_t = \sum\nolimits_{l,n} \left((\exp_k + \mathrm{imp}_k) / \left(\sum\nolimits_{l,n} \; (\exp_k + \mathrm{imp}_k) \right) {}^{*} X_{kt} \right) \tag{11}$$

where n is the number of countries included in the region, $\exp_k$ is the export flow from the U.S. towards country k, imp_k the import flow from country k towards the U.S. and X_{kt} the bilateral exchange rate between the U.S. dollar and country k's currency.[23] The weights of the region-specific indices, updated monthly, are based on each country's proportion of trade in the total import and export flows of the region with the U.S. – $\sum_{1,n}$ $(\exp_k + \mathrm{imp}_k)$ – as reported by the Foreign Trade Division of the U.S. Census Bureau.

To provide a general understanding of the nature of each exchange rate index, summary statistics of weekly log price changes are presented in Table 2.

The statistics include index returns for mean, median, maximum, minimum, standard deviation, skewness and kurtosis. All exchange rate indices experienced positive mean weekly returns during

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19 Bodnar and Wong (2003) are the first to demonstrate the importance of the definition of the stock market risk factor in the empirical assessment of foreign exchange risk exposure. Their results indicate that, because large firms are over-represented in these indices, value-weighted market indices induce a positive bias in exposure coefficients. Corroborating evidence is provided in Pantzalis et al. (2001), Dominguez and Tesar (2001) and Starks and Wei (2003).

20 To verify the robustness of our results towards the definition of the stock market index we perform all subsequent regressions with the value-weighted and the equally-weighted market index. As the choice of the market index may lead to a bias in the exposure coefficient – in line with Bodnar and Wong's (2003) findings – but has no impact on the specification and statistical relevance of the non-linear relationship between exchange rate movements and stock returns, we only report the results obtained with the value-weighted market index in the tables. However, results obtained with the equally-weighted market index are available from the authors upon request.

21 Following Jorion (1990) exchange rate indices are parsimonious representations of the effect of multiple exchange rate changes.

22 The bilateral exchange rates are expressed in units of foreign currency per U.S. dollar and have been obtained from *Datastream International*.

23 The currency movements are expressed in nominal terms. Two reasons may explain this choice. First, as financial markets do not observe inflation rates instantaneously, it is highly probable that investors are primarily incorporating the impact of nominal exchange rates in stock prices (Bodnar and Gentry, 1993). Second, since the variability of inflation differentials is typically relatively lower than the variability of exchange rates, nominal currency movements actually dominate real exchange rate movements. It has moreover been empirically shown that the use of real versus nominal exchange rates has a negligible effect on exposure estimates both for developed and emerging markets (e.g. Bodnar and Gentry, 1993; Amihud, 1994; Choi and Prasad, 1995; Chamberlain et al., 1997; Griffin and Stulz, 2001; Muller and Verschoor, 2004).

Table 1
Summary of foreign activities of U.S. multination sample firms by geographical region and industrial sector

	Europe	U.K.	Asia	Australia	L. America	Africa	Total
Agriculture, Mining (except oil and gas extraction) and Construction	11	9	9	10	12	3	17
Food, Tobacco, Textile, Wood and Paper related industries	62	67	69	39	53	13	101
Chemical and allied products	70	63	60	46	49	23	79
Oil and gas extraction, petroleum refining and related industries	20	29	27	16	23	14	38
Rubber, Leather, Stone, Clay, Glass and Concrete Products	22	16	20	8	13	3	24
Primary and fabricated metal industries*	36	37	33	18	27	8	49
Industrial and Commercial machinery and computer equip.	89	89	80	49	48	25	111
Electronic and other electrical equip. (except computer equip.)	65	80	70	31	37	13	92
Transportation equip., measuring instruments and miscellaneous	85	76	71	43	51	12	102
Transportation, communications, electric, gas and sanitary services	36	37	31	22	31	8	53
Wholesale and retail trade	35	27	31	16	27	7	57
Finance, Insurance and real estate	50	65	55	32	41	19	78
Services	102	117	83	66	49	16	134
Total	683	712	639	396	461	164	935

Definition of industry sectors: *Agriculture, Mining (except oil and gas extraction) and construction* SIC 0–1241 and 1400–1999; *Food, Tobacco, Textile, Wood and Paper related industries* SIC 2000–2799; *Chemicals and allied products* SIC 2800–2899; *Oil and gas extraction, petroleum refining and related industries* SIC 1300–1399 and 2900–2999; *Rubber, Leather, Stone, Clay, Glass and Concrete Products* SIC 3000–3299; *Primary and fabricated metal industries (*except machinery and transportation equipment)* SIC 3300–3499; *Industrial and Commercial machinery and Computer equipment* SIC 3500–3599; *Electronic and other electrical equipment (except computer equipment)* SIC 3600–3699; *Transportation equipment, measuring instruments and miscellaneous manufacturing industries* SIC 3700–3999; *Transportation, Communications, electric, gas and sanitary services* SIC 4000–4999; *Wholesale and Retail Trade* SIC 5000–5999; *Finance, Insurance and Real Estate* SIC 6000–6999; *Services* SIC 7000–8999.

the sample period. While all exchange rate series are positively skewed, the Latin American and South African exchange rate indices exhibit a particularly strong positive skewness indicating that large depreciations of these currencies were more common than large appreciations. On the other hand, the returns of the euro/U.S. dollar bilateral rate are approximately symmetrically distributed.

The coefficient of kurtosis for the Latin American, South African and Asian currency indices are much larger than 3, so that the return distribution of these exchange rate indices may be characterized as leptokurtic. In contrast, the euro/U.S. dollar bilateral rate as well as the trade-weighted world exchange rate index have a flat distribution relative to the normal. Finally, further tests indicate that for all reported series the assumption of normality is clearly violated.

Except for the correlation of 0.709 between the U.K. pound/U.S. dollar and the euro/U.S. dollar bilateral rates[24], Table 3 reveals that correlations between region-specific exchange rate indices are relatively low.

[24] Following Khoo (1994), a second set of sensitivity tests excludes the UK pound/U.S. dollar exchange rate factor as soon as the euro/U.S. dollar rate is included in any of the estimation models. This enables us to check the robustness of our results towards the impact of multicolinearity problems arising from the high correlation between these bilateral exchange rates. Results show, however, that this change has a surprisingly small effect on the estimation of the euro currency exposure of U.S. multinationals and no significant impact on the general findings of this paper.

Table 2
Summary statistics for the European, U.K., Asian, Australian, Latin American and South African/U.S. dollar exchange rate indices

	U.S. dollar trade-weighted world index	U.S. dollar versus euro	U.S. dollar versus U.K. pound	U.S. dollar versus Asian currencies	U.S. dollar versus Australian dollar	U.S. dollar versus Latin American currencies	U.S. dollar versus South African rand
Mean	0.00029	0.00037	0.00003	0.00025	0.00060	0.00379	0.00247
Median	0.00000	0.00016	−0.00062	0.00068	−0.00015	0.00300	0.00143
Maximum	0.02802	0.04247	0.03883	0.03917	0.06638	0.22743	0.12879
Minimum	−0.04132	−0.03765	−0.04036	−0.02352	−0.05183	−0.03900	−0.05375
Std. dev.	0.00904	0.01137	0.01244	0.00678	0.01207	0.01473	0.01286
Skewness	−0.22754	0.04480	0.15455	0.22802	0.41797	7.55061	2.09105
Kurtosis	1.39500	0.59704	3.37167	5.74491	3.19349	99.44950	18.42766
Observations	627	627	627	627	627	627	627

Summary statistics are for weekly log price changes from January 5, 1990 till December 31st, 2001.

We observe furthermore that the correlations between the trade-weighted world exchange rate index and the U.K. pound/U.S. dollar, the euro/U.S. dollar as well as the Asian region-specific index rates are remarkably high, indicating that the returns of trade-weighted world exchange rate index strongly followed the evolution of these exchange rate series during our sample period.[25] Finally, reported statistics show that the *CRSP value-weighted market index* is not strongly correlated with any of the included exchange risk factors.

5. Empirical findings

In this section, we provide evidence on the asymmetric sensitivity of firm-level stock returns to currency risk and we highlight the impact of the choice of the exchange rate factor on the estimation of foreign currency risk exposure. We therefore consider the summary statistics of the estimated exposure coefficients as well as the percentage of firms that are statistically significantly exposed to currency movements using the different methodologies outlined in Section 3.

5.1. Linear exchange risk exposure

Following Jorion (1990), we begin our analysis by considering whether U.S. multinationals are exposed to changes in a trade-weighted worldwide U.S. dollar exchange rate index. We therefore estimate for each firm separately the augmented market model described in Eq. (1) — respectively Eq. (2). In Table 4 where the summary statistics of the estimated coefficients are reported, several features may be observed.

First, the average market beta is 0.8717 and its median value lies at 0.7924.[26] Second, Table 4 indicates that 7.27%[27] of our sample firms are statistically significantly exposed to the worldwide

[25] As the world index is never simultaneously used with any of these region-specific currency indices, this does not lead however to any multicolinearity problem.
[26] The fact that U.S. multinationals with foreign operations tend to be less exposed to market risk than the overall U.S. market supports the view that geographical dispersion of economic activities leads to a reduction of business risk.
[27] The percentage of significantly exposed U.S. companies is slightly higher than the percentage reported by Jorion (1990) using the same estimation model.

Table 3
Correlations between exchange rate indices

	CRSP value-weighted market index	US$ trade-weighted world index	US$ versus euro	US$ versus U.K. pound	US$ versus Asian currencies	US$ versus Australian dollar	US$ versus L. American currencies
US$ trade-weighted world index	0.08414						
US$ versus euro	0.10852	0.80475					
US$ versus U.K. pound	0.07607	0.64533	0.70948				
US$ versus Asian currencies	0.02836	0.70587	0.36349	0.24275			
US$ versus Australian dollar	−0.08313	0.30121	0.20156	0.21282	0.22362		
US$ versus L. American currencies	−0.13038	−0.01969	−0.05771	0.02068	−0.02996	−0.00007	
US$ versus South African rand	−0.10332	0.32130	0.27333	0.22728	0.20648	0.13945	0.08603

Correlation statistics are for weekly log price changes from January 5, 1990 till December 31st, 2001.

exchange rate index, at least at the 5% level.[28] We observe furthermore that the mean and median currency risk exposures of our sample firms are positive. These outcomes which may appear at first glance somewhat surprising – since they imply that U.S. multinational companies generally gain from U.S. dollar appreciations – are nevertheless consistent with earlier findings (Clarida, 1992; Hung, 1992; Bodnar and Wong, 2003).[29] Two main arguments may, moreover, rationalize the fact that these multinationals benefit from a strengthening domestic currency. On the one hand, the positive valuation impact of an appreciation of the home currency may simply translate the fact that U.S. multinationals set up foreign operations for their local sales and their exporting activities to the world market. They may, for instance, be strongly dependent on raw materials as well as other input products for the production of goods intended both for their own domestic markets and for foreign markets. On the other hand, it is highly probable that our selection procedure – which is based on the *Directory of American Firms Operating in Foreign Countries* – has sorted out a large number of U.S. companies with foreign production subsidiaries. For these firms, the positive valuation effects of domestic currency appreciations are, hence, not surprising given that they are facing important foreign denominated cash outflows.

Finally, it has to be mentioned that there is overwhelming evidence that the error terms of Eq. (1) are conditionally heteroskedastic. We incorporated, indeed, GARCH(1,1) conditional variance extensions into the system for 702 (approximately 75%) stock return series of our sample.

The most noticeable difference between Tables 4 and 5 is that the estimation of region-specific currency exposures leads to a percentage of 29.09%[30] of firms that are statistically significantly exposed to currency movements. Consistent with Ihrig (2001), these results suggest that the

[28] Throughout the paper the 5% significance level is adopted.

[29] Muller and Verschoor (2006) likewise suggest that European firms gain from domestic currency appreciations. It has, however, to be stressed that the analysis across sub-periods revealed in this context that the sign of firm-level currency exposures may change through time — presumably due to the different episodes undergone by both stock and exchange rate markets.

[30] 29.09% of U.S. multinationals is exposed to one region-specific exchange rate index *at least*.

Table 4
Linear foreign exchange risk exposure — world exchange rate index

		Mean	Median	Q_1	Q_3	N*	N
Constant	α	−0.0007	−0.0003	−0.0019	0.0010		
		0.0001	*0.0001*				
Market index	β	0.8717	0.7924	0.5886	1.0919		
		0.0139	*0.0174*				
Trade weighted US$ exchange rate index	γ	0.0408	0.0553	−0.1399	0.2375	68	935
		0.0136	*0.0170*			*7.27%*	
Constant§	δ*	0.0018	0.0009	0.0004	0.0019		
		0.0001	*0.0001*				
ARCH	τ*	0.1539	0.1140	0.0666	0.1870		
		0.0072	*0.0090*				
GARCH	v*	0.4767	0.5842	0.2907	0.7689		
		0.0149	*0.0187*				

This Table reports cross-sectional summary statistics of the parameters estimated by the following regression model:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \gamma_i \theta_t + \varepsilon_{i,t}$$

where $R_{i,t}$ designates the total return of firm i in period t, $R_{m,t}$ the CRSP value-weighted stock market return in period t, β_i firm i's return sensitivity to market fluctuations, θ_t the movement in the trade-weighted world exchange rate index, γ_i firm i's exposure to the exchange rate index and $\varepsilon_{i,t}$ the white noise error term.
If, for firm i, the homoskedasticity of the error terms $\varepsilon_{i,t}$ is rejected, the previous model is extended to:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \gamma_i \theta_t + \varepsilon_{i,t} \quad \text{with} \quad \varepsilon_{i,t} = \mu_{i,t}{*}(h_{i,t})^{1/2} \; h_{i,t} = \delta_i + \tau_i \varepsilon^2_{i,t-1} + v_i h_{i,t-1}$$

where $h_{i,t}$ denotes the conditional variance of the residuals; δ_i, τ_i and v_i unknown parameters; and $\mu_{i,t}$ represents the white noise error term.
The numbers are summary statistics of the cross-sectional distribution of the ordinary least squares parameter estimates of Eq. (1), respectively the maximum likelihood (using the Berndt et al., 1974 algorithm) parameter estimates of Eq. (2). Q_1 and Q_3 represent the first and third quartiles of the distribution, respectively. For mean and median values, standard deviations are reported in italics. *These results are reported when the homoskedasticity of the error terms $\varepsilon_{i,t}$ in Eq. (1) is rejected. §The constant δ_i of Eq. (2). N* is the number of firms with a documented significant exchange rate exposure at the 5% level. N is the size of the total sample.

construction of a firm-specific exchange risk factor based on the geographical dispersion of a firm's activities significantly improves the precision of individual firm-level currency risk exposure estimates. Moreover the disaggregation of the trade-weighted world exchange rate index into region-specific currency indices avoids the loss of information due to low or negative correlations between exchange rate series and, hence, improves the informative quality of our exchange risk factor. Finally, we note that U.S. multinationals are particularly sensitive to Asian exchange rate movements. Out of 639 firms that are active in this region, 110 (17.21%) are significantly exposed to changes in the Asian currency market.

In order to analyze the impact of these region-specific foreign exchange rate movements on different industries, the percentage of firms with significant currency exposure is calculated by industry sector (Table 6).

The industries where we find most firms with statistically significant currency risk exposures are agriculture, mining (except oil and gas extraction) and construction; wholesale and retail trade; finance, insurance and real estate; and services.[31] These results are not surprising since these industries are by their very nature and their extreme internationalization highly exposed to currency fluctuations. It is also important to note that the sensitivity to Asian exchange rate movements is also remarkably strong for the electronic and other electrical equipment (except

[31] These findings are in line with previous empirical findings (see, for example, Muller and Verschoor, 2006).

Table 5
Linear foreign exchange risk exposure — regional exchange rate indices

		Mean	Median	Q_1	Q_3	N^*	N
Constant	α	−0.0007	−0.0002	−0.0327	0.0131		
		0.0001	*0.0001*				
CRSP value-weighted market index	β	0.8725	0.7806	0.5881	1.0998		
		0.0138	*0.0173*				
Trade weighted US$ exchange rate index versus Europe	γ_{EU}	0.0169	0.0162	−0.1557	0.2140	61	683
		0.0155	*0.0194*			*8.93%*	
Trade weighted US$ exchange rate index versus U.K.	γ_{UK}	0.0662	0.0550	−0.1000	0.2173	66	712
		0.0136	*0.0171*			*9.27%*	
Trade weighted US$ exchange rate index versus Asia	γ_{AS}	0.0274	0.0494	−0.2182	0.2862	110	639
		0.0182	*0.0229*			*17.21%*	
Trade weighted US$ exchange rate index versus Australia	γ_{AU}	−0.0971	−0.0741	−0.2871	0.0935	36	396
		0.0168	*0.0211*			*9.09%*	
Trade weighted US$ exchange rate index versus Latin America	γ_{LA}	0.0064	0.0016	−0.0745	0.0899	44	461
		0.0107	*0.0135*			*9.54%*	
Trade weighted US$ exchange rate index versus South Africa	γ_{SA}	0.0094	−0.0180	−0.1188	0.1324	15	164
		0.0192	*0.0240*			*9.15%*	
Constant[§]	δ^*	0.0017	0.0008	0.0004	0.0018		
		0.0001	*0.0001*				
ARCH	τ^*	0.1626	0.1178	0.0673	0.1901		
		0.0080	*0.0100*				
GARCH	v^*	0.4812	0.5944	0.2623	0.7657		
		0.0148	*0.0185*				
Total number of companies that are significantly exposed to one currency index at least:						272	935
						29.09%	

This Table reports cross-sectional summary statistics of the estimation of the following regression model:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \Gamma_i \Theta_t + \varepsilon_{i,t}$$

and

$$\Gamma_i \Theta_t = \gamma_{\mathrm{EU},i}\theta_{\mathrm{EU},t}{}^*D_{\mathrm{EU},i} + \gamma_{\mathrm{UK},i}\theta_{\mathrm{UK},t}{}^*D_{\mathrm{UK},i} + \gamma_{\mathrm{AS},i}\theta_{\mathrm{AS},t}{}^*D_{\mathrm{AS},i} + \gamma_{\mathrm{AU},i}\theta_{\mathrm{AU},t}{}^*D_{\mathrm{AU},i} + \gamma_{\mathrm{LA},i}\theta_{\mathrm{LA},t}{}^*D_{\mathrm{LA},i} + \gamma_{\mathrm{SA},i}\theta_{\mathrm{SA},t}{}^*D_{\mathrm{SA},i}$$

where $R_{i,t}$ designates the total return of firm i in period t, $R_{m,t}$ the CRSP value-weighted stock market return in period t, β_i firm i's return sensitivity to market fluctuations, $\theta_{j,t}$ the movement in the region j specific trade-weighted U.S. dollar exchange rate index, $D_{j,i}$ a dummy variable that takes the value 1 if firm i has real activities in region j, $\gamma_{j,i}$ firm i's exposure to the region j specific trade-weighted U.S. dollar exchange rate index and $\varepsilon_{i,t}$ the white noise error term.
If, for firm i, the homoskedasticity of the error terms $\varepsilon_{i,t}$ is rejected, the model is extended to:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \Gamma_i \Theta_t + \varepsilon_{i,t} \qquad \text{with } \varepsilon_{i,t} = \mu_{i,t}{}^*(h_{i,t})^{1/2} \quad \text{and} \quad h_{i,t} = \delta_i + \tau_i \varepsilon_{i,t-1}^2 + v_i h_{i,t-1}$$

where $h_{i,t}$ denotes the conditional variance of the residuals; δ_i, τ_i and v_i unknown parameters; and $\mu_{i,t}$ represents the white noise error term.
Reported numbers are summary statistics of the cross-sectional distribution of the ordinary least squares parameter estimates of Eq. (3), respectively the maximum likelihood (using the Berndt et al., 1974 algorithm) parameter estimates of Eq. (4). Q_1 and Q_3 denote the first and third quartiles of the distribution. For mean and median values, standard deviations are reported in italics. *These results are reported when the homoskedasticity of the error terms $\varepsilon_{i,t}$ in Eq. (3) is rejected. [§]The constant δ_i of Eq. (4). N^* designates the number of firms with a documented significant (at the 5% level) exchange rate exposure to one of the regional currency indices. N is the total number of firms that have activities in the corresponding geographical region.

Table 6
Linear foreign exchange risk exposure

	Europe	U.K.	Asia	Australia	Latin America	Africa	Total
Agriculture, Mining (except oil and gas extraction) and Construction	0.00%	11.11%	55.56%	70.00%	33.33%	33.33%	35.29%
Food, Tobacco, Textile, Wood and Paper related industries	12.90%	10.45%	18.84%	12.82%	16.98%	15.38%	17.82%
Chemical and allied products	12.86%	17.46%	18.33%	19.57%	22.45%	34.78%	27.85%
Oil and gas extraction, petroleum refining and related industries	0.00%	0.00%	7.41%	0.00%	4.35%	7.14%	21.05%
Rubber, Leather, Stone, Clay, Glass and Concrete Products	9.09%	12.50%	10.00%	12.50%	7.69%	33.33%	12.50%
Primary and fabricated metal industries*	16.67%	16.22%	15.15%	16.67%	11.11%	12.50%	28.57%
Industrial and Commercial machinery and computer equip.	12.36%	15.73%	16.25%	26.53%	22.92%	24.00%	31.53%
Electronic and other electrical equip. (except computer equip.)	12.31%	15.00%	28.57%	29.03%	13.51%	0.00%	29.35%
Transportation equip., measuring instruments and miscellaneous	17.65%	14.47%	7.04%	20.93%	15.69%	8.33%	18.63%
Transportation, communications, electric, gas and sanitary services	16.67%	29.73%	12.90%	18.18%	6.45%	0.00%	18.87%
Wholesale and retail trade	28.57%	18.52%	58.06%	18.75%	25.93%	28.57%	38.60%
Finance, Insurance and real estate	28.00%	20.00%	43.64%	18.75%	29.27%	15.79%	50.00%
Services	13.73%	12.82%	39.76%	9.09%	20.41%	18.75%	36.57%
Total	8.93%	9.27%	17.21%	9.09%	9.54%	9.15%	29.09%

Reported percentages represent – per industry sector – the ratio between the number of firms that are significantly exposed to the European, U.K., Asian, Australian, Latin American, respectively South African exchange rate index and the number of firms that are active in the corresponding region.
Definition of industry sectors: see Table 1.

computer equipment) sector. Given the truly intense trading relationships that exist between these U.S. and Asian industry sectors, this finding is likewise consistent with our expectations.

In order to investigate the possible non-linearity of the relationship between exchange rate movements and stock returns, we perform in a first stage a LM test of the null hypothesis of linearity against a nonspecified nonlinear alternative as suggested in Granger and Teräsvirta (1993).[32] We observe that linearity is strongly rejected for almost 69% of firms in our sample encouraging us to verify in how far the model Eqs. (6) and (7) allowing for sign-asymmetries and the model Eqs. (8) and (9) integrating magnitude-asymmetries offer a plausible parametrization of the detected nonlinear behavior.[33]

5.2. Sign-asymmetries in exchange risk exposure

Table 7 reports the findings of the augmented market model Eq. (6) respectively Eq. (7) that takes sign asymmetries in the estimation of currency exposure coefficients into account.

[32] We use the auxiliary regression suggested in Granger and Teräsvirta (1993) approximating the transition function by a third order Taylor series expansion as alternative hypothesis in our linearity test.

[33] It should be noted that the regression models described in Eqs. (6) and (7) and Eqs. (8) and (9) have been performed for all firms of the sample. Results focusing exclusively on firms for which the linearity hypothesis has been rejected are available from the authors upon request.

Results show that for 15.72% of all selected U.S. multinationals the null hypothesis of symmetric currency exposure against the alternative allowing for sign asymmetries is strongly rejected. More specifically, for 41.67% (100 of 240) of firms with documented significant exchange rate exposure, the exposure is shown to be asymmetric during appreciations and depreciations. Furthermore, we observe that γ and γ' coefficients are generally of opposite sign. The asymmetry coefficients, whose mean value lies at 0.61, reveal moreover that the reaction to U.S. dollar appreciations is on average stronger in magnitude compared to the reaction to U.S. dollar depreciations.[34] It is interesting to note that these results are consistent with the findings of Koutmos and Martin (2003a) who analyzed industry portfolios.[35] The nonlinear specification of the model enables us moreover to detect 353 U.S. multinationals (37.75%) that are – linearly *or* asymmetrically – exposed to currency movements. This increases the number of documented exchange risk exposures by approximately 30% as compared to the linear model. It has to be noticed that the nonlinear model highlights particularly the impact of Asian as well as Latin American currency movements on U.S. firm value. Ultimately, it should be pointed out that U.S. multinationals appear to be predominantly affected by U.S. dollar appreciations. One potential explanation for this finding could be that U.S. firms are probably able to hedge the adverse effects resulting from their short foreign currency positions in a more efficient way than they are hedging the economic exposure effects resulting from a loss of competitiveness due to an appreciation of their domestic currency. However, many other justifications may be advanced[36] and further empirical evidence is needed to truly validate these different theories.

5.3. Magnitude-asymmetries in exchange risk exposure

In Table 8, we report the estimates of the model outlined in Eqs. (8) and (9).

Several important points can be drawn from the results. As we anticipated, the inclusion of size-asymmetries in the estimation of currency exposures enables us to detect the nonlinear nature of exchange risk exposures. Allowing for asymmetry in decreasing and increasing exchange rate movements, it appears that 56.04% of U.S. multinationals is significantly affected by currency movements. The number of firms with documented significant exchange risk exposures is, thus, approximately two times higher compared to the linear model and 50% higher compared to the model including size-asymmetries. Moreover, it appears that among empirically significant exchange rate exposures, the currency sensitivity turns out to be asymmetric over large and small movements in almost 75% (216 of 289) of the cases.[37] Taking into account the complete sample of U.S. multinationals, we observe, further, that the null hypothesis of a linear relationship between exchange rate movements and stock returns – against the alternative allowing for size asymmetries – is rejected for 26.42% of our sample companies. These results, in comparison with the previous reported models, are peculiarly striking. They suggest that models assuming symmetric exposure over small and large exchange rate movements are very frequently misspecified. They are, thus, not able to detect the link between

[34] Summary statistics of these asymmetry coefficients are provided by the authors upon request.

[35] Their results show indeed that 42.9% of the industry portfolios with significant exchange rate exposure are found to be asymmetric during appreciations and depreciations and that γ and γ' coefficients are similarly of opposite sign.

[36] Please refer to Section 2 of this paper.

[37] Not surprisingly, regarding the Asian and Latin American currencies, we note that the percentage of significant currency exposures that turns out to be asymmetric is even stronger. This can easily be explained by the higher volatility of these currency markets.

Table 7
Non-linear foreign exchange risk exposure — sign asymmetries

		Mean	Median	Q_1	Q_3	N^*	N
Constant	α	−0.0002	0.0000	−0.0027	0.0024		
		0.0002	*0.0002*				
Market index	β	0.8730	0.7847	0.5862	1.0985		
		0.0139	*0.0174*				
Trade weighted US$ exchange rate index versus Europe	γ_{EU}	0.0693	0.0670	−0.2651	0.3742	55	683
		0.0255	*0.0320*			*8.05%*	
	γ_{EU}'	−0.0952	−0.0801	−0.5714	0.3782	47	
		0.0409	*0.0512*			*6.88%*	
Trade weighted US$ exchange rate index versus U.K.	γ_{UK}	0.0747	0.0360	−0.1642	0.2909	55	712
		0.0221	*0.0277*			*7.72%*	
	γ_{UK}'	−0.0342	0.0303	−0.3419	0.3573	49	
		0.0359	*0.0450*			*6.88%*	
Trade weighted US$ exchange rate index versus Asia	γ_{AS}	−0.1051	−0.0152	−0.4415	0.3307	79	639
		0.0314	*0.0394*			*12.36%*	
	γ_{AS}'	0.2264	0.1321	−0.4328	0.8328	64	
		0.0490	*0.0614*			*10.02%*	
Trade weighted US$ exchange rate index versus Australia	γ_{AU}	−0.1532	−0.1523	−0.3835	0.1027	29	396
		0.0249	*0.0311*			*7.32%*	
	γ_{AU}'	0.1261	0.0870	−0.3203	0.4693	32	
		0.0405	*0.0507*			*8.08%*	
Trade weighted US$ exchange rate index versus America	γ_{LA}	−0.0129	−0.0220	−0.1024	0.0671	51	461
		0.0121	*0.0152*			*11.06%*	
	γ_{LA}'	0.1312	0.1282	−0.1898	0.4908	41	
		0.0376	*0.0471*			*8.89%*	
Trade weighted US$ exchange rate index versus Africa	γ_{SA}	−0.0262	−0.0497	−0.1584	0.0877	16	164
		0.0251	*0.0314*			*9.76%*	
	γ_{SA}'	0.1077	0.0533	−0.2989	0.4956	13	
		0.0570	*0.0714*			*7.93%*	
Constant[§]	δ^*	0.0016	0.0008	0.0004	0.0018		
		0.0001	*0.0001*				
ARCH	τ^*	0.1705	0.1196	0.0678	0.1992		
		0.0083	*0.0104*				
GARCH	ν^*	0.4732	0.5803	0.2581	0.7647		
		0.0150	*0.0188*				

exchange rate movements and stock returns and tend to underestimate the impact of currency movements on firm value. When considering the impact of large versus small exchange rate movements, our findings unanimously reveal that, in spite of the fact that the exposure coefficients ($\Gamma_i+\Gamma_i'$) towards large currency movements are generally smaller in magnitude compared to the coefficients Γ_i towards small currency movements[38], the valuation effects of large currency shocks are statistically and economically more relevant in terms of firm value. This series of results sheds new light on various issues that have already been thoroughly discussed in this paper: firstly, it may lend support to the hypothesis that investors find it particularly difficult to forecast the valuation effects of small currency fluctuations; secondly, it

[38] The average value of the asymmetry coefficients $(\Gamma_i+\Gamma_i')/\Gamma_i$ is 0.65. Summary statistics of these asymmetry coefficients are provided by the authors upon request.

Table 7 (*continued*)

	N^*	N
Total number of companies that are – linearly and asymmetrically – significantly exposed to at least one currency index:	353 *37.75%*	935
Total number of companies that are – linearly or asymmetrically – significantly exposed to at least one currency index:	100 *10.70%*	935
Number of companies for which the likelihood ratio test rejects the null hypothesis of linear currency exposure†:	147 *15.72%*	935

This Table reports cross-sectional summary statistics of the parameters estimated by the following regression model:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + (\Gamma_i + \Gamma_i{}'S_t)^*\Theta_t + \varepsilon_{i,t}$$

$$\text{With} \quad \Gamma_i\Theta_t = \gamma_{\mathrm{EU},i}\theta_{\mathrm{EU},t}{}^*D_{\mathrm{EU},i} + \gamma_{\mathrm{UK},i}\theta_{\mathrm{UK},t}{}^*D_{\mathrm{UK},i} + \gamma_{\mathrm{AS},i}\theta_{\mathrm{AS},t}{}^*D_{\mathrm{AS},i} + \gamma_{\mathrm{AU},i}\theta_{\mathrm{AU},t}{}^*D_{\mathrm{AU},i} + \gamma_{\mathrm{LA},i}\theta_{\mathrm{LA},t}{}^*D_{\mathrm{LA},i} + \gamma_{\mathrm{SA},i}\theta_{\mathrm{SA},t}{}^*D_{\mathrm{SA},i}$$

$$\text{and} \quad \Gamma_i{}'S_t\Theta_t = \gamma_{\mathrm{EU},i}{}'\theta_{\mathrm{EU},t}S_{\mathrm{EU},t}{}^*D_{\mathrm{EU},i} + \gamma_{\mathrm{UK},i}{}'\theta_{\mathrm{UK},t}S_{\mathrm{UK},t}{}^*D_{\mathrm{UK},i} + \gamma_{\mathrm{AS},i}{}'\theta_{\mathrm{AS},t}S_{\mathrm{AS},t}{}^*D_{\mathrm{AS},i} + \gamma_{\mathrm{AU},i}{}'\theta_{\mathrm{AU},t}S_{\mathrm{AU},t}{}^*D_{\mathrm{AU},i} + \gamma_{\mathrm{LA},i}{}'\theta_{\mathrm{LA},t}S_{\mathrm{LA},t}{}^*D_{\mathrm{LA},i} + \gamma_{\mathrm{SA},i}{}'\theta_{\mathrm{SA},t}S_{\mathrm{SA},t}{}^*D_{\mathrm{SA},i}$$

where $R_{i,t}$ designates the total return of firm i in period t, $R_{m,t}$ the CRSP value-weighted stock market return in period t, β_i firm i's return sensitivity to market fluctuations, $\theta_{j,t}$ the movement in region j's specific trade-weighted U.S. dollar exchange rate index in period t, $D_{j,i}$ a dummy variable that takes the value 1 if firm i has real activities in region j, $S_{j,t}$ a dummy variable that takes the value 1 if $\theta_{j,t}$ is negative, $\gamma_{j,i}$ firm i's symmetric exposure to region j's specific trade-weighted U.S. dollar exchange rate index, $\gamma_{j,i}'$ firm i's asymmetric exposure to region j's specific trade-weighted U.S. dollar exchange rate index and $\varepsilon_{i,t}$ the white noise error term.
If, for firm i, the homoskedasticity of the error terms $\varepsilon_{i,t}$ of Eq. (6) is rejected, the model is extended to:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + (\Gamma_i + \Gamma_i{}'S_t)^*\Theta_t + \varepsilon_{i,t} \quad \text{with} \quad \varepsilon_{i,t} = \mu_{i,t}{}^*(h_{i,t})^{1/2} \;\; h_{i,t} = \delta_i + \tau_i\varepsilon_{i,t-1}^2 + v_i h_{i,t-1}$$

where $h_{i,t}$ denotes the conditional variance of the residuals; δ_i, τ_i and v_i unknown parameters; and $\mu_{i,t}$ represents the white noise error term.
The numbers are summary statistics of the cross-sectional distribution of the ordinary least squares parameter estimates of Eq. (6), respectively the maximum likelihood (using the Berndt et al., 1974 algorithm) parameter estimates of Eq. (7). Q_1 and Q_3 represent the first and third quartiles of the distribution, respectively. For mean and median values, standard deviations are reported in italics. *These results are reported when the homoskedasticity of the error terms $\varepsilon_{i,t}$ in Eq. (6) is rejected. §The constant δ_i of Eq. (7). N^* designates the number of firms with a documented significant exchange rate exposure to the regional currency index at the 5 percent level. N is the total number of firms that have activities in the corresponding geographical region. †The likelihood ratio test is performed against the alternative hypothesis that stock returns react asymmetrically to positive versus negative exchange rate movements.

pleads for the view that increased exchange rate variability constitutes a particularly influential source of risk for companies; thirdly, it may indicate that companies are facing difficulties in implementing efficient hedging activities when exchange rate markets undergo turbulent market conditions; finally, it may as well reveal that pass-through effects are positively linked to the magnitude of exchange rate movements (Ohno, 1989; Pollard and Coughlin, 2003) and/or that large currency fluctuations lead to market entry or exit decisions that are not overruled when the foreign currency returns progressively to its initial value.

6. Concluding remarks

Previous empirical literature on foreign exchange risk exposure suggests that there is weak evidence on the sensitivity of U.S. stock returns to exchange rate movements. This paper examines the impact of the linearity assumption on the estimation of foreign exchange risk exposure of U.S.

Table 8
Non-Linear foreign exchange risk exposure — size asymmetries

		Mean	Median	Q_1	Q_3	N*	N
Constant	α	−0.0009	−0.0006	−0.0022	0.0010		
		0 .0001	*0.0001*				
Market index	β	0.8745	0.7855	0.5911	1.1082		
		0.0137	*0.0172*				
Trade weighted US$ exchange rate index versus Europe	γ_{EU}	0.1193	0.1122	−0.3277	0.5959	78	683
		0.0350	*0.0438*			*11.42%*	
	$\gamma_{EU'}$	−0.1244	−0.0310	−0.7330	0.3421	141	
		0.0426	*0.0534*			*20.64%*	
Trade weighted US$ exchange rate index versus U.K.	γ_{UK}	−0.0290	−0.0193	−0.4349	0.3603	78	712
		0.0345	*0.0432*			*10.96%*	
	$\gamma_{UK'}$	0.1110	0.0275	−0.3030	0.5360	134	
		0.0378	*0.0474*			*18.82%*	
Trade weighted US$ exchange rate index versus Asia	γ_{AS}	−0.1391	−0.0130	−0.8123	0.7065	79	639
		0.0688	*0.0862*			*12.36%*	
	$\gamma_{AS'}$	0.1986	0.0318	−0.7737	0.9658	133	
		0.0815	*0.1022*			*20.81%*	
Trade weighted US$ exchange rate index versus Australia	γ_{AU}	−0.1401	−0.1205	−0.4517	0.2424	33	396
		0.0368	*0.0461*			*8.33%*	
	$\gamma_{AU'}$	0.0446	0.0213	−0.3841	0.4058	54	
		0.446	*0.0559*			*13.64%*	
Trade weighted US$ exchange rate index versus Latin America	γ_{LA}	0.1630	0.1635	−0.0903	0.4641	68	461
		0.0294	*0.0368*			*14.75%*	
	$\gamma_{LA'}$	−0.1684	−0.1727	−0.5277	0.0753	98	
		0.0309	*0.0388*			*21.26%*	
Trade weighted US$ exchange rate index versus South Africa	γ_{SA}	0.0767	0.0912	−0.2231	0.3711	16	164
		0.0422	*0.0529*			*9.76%*	
	$\gamma_{SA'}$	−0.0679	−0.0104	−0.4414	0.2102	23	
		0.0481	*0.0603*			*14.02%*	
Constant[§]	δ^*	0.0016	0.0008	0.0004	0.0017		
		0.0001	*0.0001*				
ARCH	τ^*	0.1727	0.1204	0.0644	0.2008		
		0.0087	*0.0109*				
GARCH	ν^*	0.4826	0.5957	0.2745	0.7626		
		0.0149	*0.0187*				

multinationals. It uses a new extensive data set of 935 U.S. companies with real operations in foreign countries and tests the hypothesis that stock returns react differentially both to positive versus negative news from exchange rate markets and to large versus small currency shocks.

First, empirical findings show that the disaggregation of the worldwide trade-weighted U.S. dollar exchange rate index into six region-specific trade-weighted indices increases the precision and significance of exposure estimates. Results show furthermore that the inclusion of both sign and size asymmetries significantly increases the number of U.S. companies that document a significant sensitivity to currency movements. For 41.67% (100 of 240) of firms with documented significant exchange rate exposure, the exposure is shown to be asymmetric during appreciations and depreciations. On the other hand, it appears that among empirically significant exchange rate exposures, the currency sensitivity turns out to be asymmetric over large and small movements in almost 75% (216 of 289) of the cases. This could be interpreted as evidence that size asymmetries are of greater importance than sign asymmetries when estimating the link between stock returns and currency movements.

Table 8 (*continued*)

	N^*	N
Total number of companies that are – linearly or asymmetrically – significantly exposed to at least one currency index:	524 *56.04%*	935
Total number of companies that are – linearly and asymmetrically – significantly exposed to at least one currency index:	216 *23.10%*	935
Number of companies for which the likelihood ratio test rejects the null hypothesis of linear currency exposure†:	247 *26.42%*	935

This Table reports cross-sectional summary statistics of the estimation of the following regression model:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + (\Gamma_i + \Gamma_i'^{*} F_i(u_t;\ k_i,\ \lambda_i))^{*}\Theta_t + \varepsilon_{i,t}$$

With $\Gamma_i\Theta_t = \gamma_{\mathrm{EU},i}\theta_{\mathrm{EU},t}{}^{*}D_{\mathrm{EU},i} + \gamma_{\mathrm{UK},i}\theta_{\mathrm{UK},t}{}^{*}D_{\mathrm{UK},i} + \gamma_{\mathrm{AS},i}\theta_{\mathrm{AS},t}{}^{*}D_{\mathrm{AS},i} + \gamma_{\mathrm{AU},i}\theta_{\mathrm{AU},t}{}^{*}D_{\mathrm{AU},i} + \gamma_{\mathrm{LA},i}\theta_{\mathrm{LA},t}{}^{*}D_{\mathrm{LA},i} + \gamma_{\mathrm{SA},i}\theta_{\mathrm{SA},t}{}^{*}D_{\mathrm{SA},i}$

and $F_i(u_t;\ k_i,\ \lambda_i) = (1 + \exp(-(u_t - k_i{}^{*}\ \bar{u}_t)^{*}\lambda_i))^{-1}$

where $R_{i,t}$ designates the total return of firm i in period t, $R_{m,t}$ the CRSP value-weighted stock market return in period t, β_i firm i's return sensitivity to market fluctuations, $\theta_{j,t}$ the movement in region j's specific trade-weighted U.S. dollar exchange rate index in period t, $D_{j,i}$ a dummy variable that takes the value 1 if firm i has real activities in region j, $F(u_t; k_i, \lambda_i)$ a transition function that is bounded between 0 and 1 and depends on the magnitude of region j's specific exchange rate index movement "$u_{j,t}$" defined as the squared of region j's specific exchange rate index movement in week t, $\gamma_{j,i}$ firm i's symmetric exposure to region j's specific trade-weighted U.S. dollar exchange rate index, $\gamma'_{j,i}$ firm i's asymmetric exposure to region j's specific trade-weighted U.S. dollar exchange rate index and $\varepsilon_{i,t}$ the white noise error term.
If, for firm i, the homoskedasticity of the error terms ε_{it} of Eq. (8) is rejected, the model is extended to:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + (\Gamma_i + \Gamma_i'^{*} F_i(u_t;\ k_i,\ \lambda_i))^{*}\Theta_t + \varepsilon_{i,t} \quad \text{with} \quad \varepsilon_{i,t} = \mu_{i,t}{}^{*}(h_{i,t})^{1/2}\ \ h_{i,t} = \delta_i + \tau_i\varepsilon_{i,t-1}^2 + v_i h_{i,t-1}$$

where $h_{i,t}$ denotes the conditional variance of the residuals; δ_i, τ_i and v_i unknown parameters; and $\mu_{i,t}$ represents the white noise error term.
The numbers are summary statistics of the cross-sectional distribution of the ordinary least squares parameter estimates of Eq. (8), respectively the maximum likelihood (using the Berndt et al., 1974 algorithm) parameter estimates of Eq. (9). Q_1 and Q_3 represent the first and third quartiles of the distribution, respectively. For mean and median values, standard deviations are reported in italics. *These results are reported when the homoskedasticity of the error terms $\varepsilon_{i,t}$ in Eq. (8) is rejected. §The constant δ_i of Eq. (9). N^* designates the number of firms with a documented significant exchange rate exposure to the regional currency index at the 5 percent level. N is the total number of firms that have activities in the corresponding geographical region. †The likelihood ratio test is performed against the alternative hypothesis that stock returns react asymmetrically to large versus small exchange rate movements.

Finally, results are highly robust to a number of changes in the model specification. The impact of redefining the market index return and excluding the U.K. pound/U.S. dollar exchange rate movements are consecutively examined. Although the significance of exposure coefficients is found to depend on the definition of the market index, the conclusions regarding the impact of asymmetries remain unaffected.

This paper provides hence strong and robust evidence that U.S. multinationals are significantly affected by exchange rate movements. We show that previous weak evidence may be attributed to the failure to account for the asymmetric nature of currency risk exposure and the use of too aggregated exchange rate indices. Empirical findings reveal furthermore that, compared to the direction, the magnitude of currency movements has a particularly strong influence on firms' sensitivity to exchange rate fluctuations. These unique results inevitably shed extra light on the underlying mechanism of foreign exchange risk exposure and provide stimulating routes for future research. The empirical investigation of the role played by corporate hedging activities, pass-through effects and hysteretic behavior as well as the influence of investors' mispricing errors and external interventionism will not only help us to assess the importance of all these forces in the determination of the exact asymmetric nature of foreign currency exposure. It will also enable us to identify other sources of time-variation that are embedded in the relationship between exchange rate movements and stock returns. These very challenging areas of research belong definitely to the most promising ways to develop precise and exhaustive techniques to appraise, understand and manage foreign exchange rate risk.

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