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Based on basic financial models and reports in the business press, exchange rate movements are generally believed to affect the value of nonfinancial firms. In contrast, the empirical research on nonfinancial firms typically produces fewer significant exposures estimates than researchers expect, independent of the sample studied and the methodology used, giving rise to a situation known as “the exposure puzzle”. This paper provides a survey of the existing research on the exposure phenomenon for nonfinancial firms. We suggest that the exposure puzzle may not be a problem of empirical methodology or sample selection as previous research has suggested, but is simply the result of the endogeneity of operative and financial hedging at the firm level. Given that empirical tests estimate exchange exposures net of corporate hedging, both, firms with low gross exposure that do not need to hedge, as well as firms with large gross exposures that employ one or several forms of hedging, may exhibit only weak exchange rate exposures net of hedging. Consequently, empirical tests yield only small percentages of firms with significant stock price exposures in almost any sample.

Keywords: Exposure, risk management, derivatives, corporate finance, exchange rates

JEL Classification: G3, F4, F3

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Based on basic financial models and reports in the business press, exchange rate movements are generally believed to affect the value of nonfinancial firms. In contrast, the empirical research on nonfinancial firms typically produces fewer significant exposures estimates than researchers expect, independent of the sample studied and the methodology used, giving rise to a situation known as “the exposure puzzle”. This paper provides a survey of the existing research on the exposure phenomenon for nonfinancial firms. We suggest that the exposure puzzle may not be a problem of empirical methodology or sample selection as previous research has suggested, but is simply the result of the endogeneity of operative and financial hedging at the firm level. Given that empirical tests estimate exchange exposures net of corporate hedging, both, firms with low gross exposure that do not need to hedge, as well as firms with large gross exposures that employ one or several forms of hedging, may exhibit only weak exchange rate exposures net of hedging. Consequently, empirical tests yield only small percentages of firms with significant stock price exposures in almost any sample.

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1 Introduction

Simple cash flow models of firms as well as anecdotal evidence from business press suggests that unexpected exchange rate changes affect the value of corporations with foreign-currency based activities, assets and/or competition. Surprisingly, empirical studies attempting to measure the exchange rate exposure of nonfinancial firms have met with only limited success in documenting statistically significant exposures for most firms, even when these firms are pre-identified based upon the factors mentioned above. In most studies, the percentage of firms with statistically significant exposures tends to be only about twice the chosen level of statistical significance. This phenomenon is presented as being inconsistent with researchers' priors and has given rise to the term "exposure puzzle". To this end, this paper systematically analyzes the existing empirical evidence of the exposure phenomenon and attempts to understand the possible source of the exposure puzzle.¹

The literature on exchange rate exposures has largely focused on attempting to solve the exposure puzzle on the basis of shortcomings in the way exchange rate exposures are estimated. The existing empirical studies cover a wide variety of approaches both in terms of the selectivity of the firms (targeted subsamples versus entire populations), the level of analysis (individual firms versus industry portfolios), and the geographic coverage (single country versus multi-countries). The studies also vary in terms of their model construction, primarily in the choice of the dependent variable but also in terms of the control variables, the choice of the measure for exchange rates, and the data/return frequency. The methodological approaches considered to explain the exposure puzzle include the possibility of time-variation in the exposure estimate,

¹ The focus of this paper is exclusively on nonfinancial firms, since firms in the financial sector are characterized by different attitudes towards financial risks given their business objectives.

lagged exposures rather than purely contemporaneous exposure effects, altering the return horizon over which the exposure is estimated, and allowing for nonlinear exposures. While each of these has been shown to be a legitimate problem of the standard simple linear exposure model using monthly returns, these modifications in general do not appear to be able to satisfactorily explain the low number of firms with significant exposures to foreign exchange rate risk. Our review of this research suggests that a majority of these studies still find significant exposures in just 10–25% of the cases (with marginally higher percentages for firms in open, export-oriented economies and nonlinear exposures), a level that still appears to be below the prior expectations of the researchers based upon theoretical and anecdotal predictions.

To be clear, this paper in no way suggests that exposure is a non-event. Despite the low levels of significance, a large number of studies demonstrate that exchange rate exposures are related to measures of international business (primarily the percentage of foreign sales), firm size, firm liquidity, as well as industry sectors in a manner that is consistent with the predictions of financial theory. There is also a relationship between the volatility of exchange rates and stock prices that is in line with exchange rate exposure. It is clear that exchange rate exposure is real, statistically significant and consistent with the predictions of financial theory for some firms, just not for as large a percentage of firms as suggested by the researchers' priors. The general tone of most papers has been that something remains amiss, hence the issue of "the exposure puzzle".

In contrast to the methodological explanations, we present the argument that the exposure puzzle is mostly the result of overly optimistic prior assumptions on the part of researcher about the extent of significant exposures within a population of firms. Put simply, the true percentage of firms with statistically identifiable exposures is not as high as researchers have lead readers to expect due to the failure to recognize endogenous exposure reducing actions on the part of firms

with large underlying exposures. Such exposure reducing actions include both financial hedging activities and operational hedging activities. Financial hedging, through the use of foreign currency derivatives or other financial instruments, primarily reduces cash flow volatility in the near term.² Operational hedging, either utilizing pre-designed flexibility in production or sourcing or reactive changes in activities, such as pricing practices and marketing decisions in response to particular movements in exchange rates, reduces the long-term impact of exchange rate changes on firm value. As we will demonstrate, these actions, often difficult for the empirical researcher to observe and measure completely and accurately, can dramatically reduce the exchange rate exposure relative to a naïve forecast based upon only easy-to-observe firm characteristics. In addition, rationality suggests that the firms most likely to engage in this type of exposure reducing activity are the firms with the largest underlying exposures. Combine this situation with the enthusiasm of researchers in this area for wanting exposures to be as prevalent as possible and we are suggesting that the source of the exposure puzzle lies more with the naïve prior beliefs that need to be updated rather than purely fundamental methodological problems with the estimation of the exposures.

To support this view, we use a simple model of exposure elasticity to demonstrate the substantial impact of operational hedging on exposure elasticities. This effect of operational hedging, combined with the potential dynamic reactions of firms' operations to exchange rate changes, suggest that the exposure of firms could be substantially less than predicted based upon observable firm characteristics. This argument is further supported by evidence on the nature of

² Recent evidence of 7,319 nonfinancial firms from 50 countries documents that 60% of the firms use derivatives in general, while 45% use currency derivatives, 33% use interest rate derivatives, and only 10% use commodity price derivatives (Bartram et al., 2003). The theoretical literature suggest several motivations for corporate hedging due to capital market imperfections such as bankruptcy costs, a convex tax schedule, or underinvestment problems (see e.g. Smith and Stulz, 1985; Bessembinder, 1991; Froot, Scharfstein, and Stein, 1993; Bartram, 2002; Bartram, 2000).

firms' financial derivative usage. The endogeneity and extent of financial hedging by firms is also consistent with a lower prevalence of significant exposures than predicted by financial models based upon observable firm characteristics.

The paper is organized as follows: Section 2 presents a comprehensive overview of the empirical results of existing studies of the exchange rate exposure phenomenon and how it is perceived as a puzzle. Subsequently, Section 3 discusses how the empirical evidence can be rationalized and the empirical evidence be interpreted in order to explain the exposure puzzle. Lastly, Section 4 concludes.

2 Exposure to Exchange Rate Risk and the Exposure Puzzle

The basic methodology used by academics for measuring exchange rate exposure is to use a simple linear regression of stock returns on the innovation in an exchange rate variable. The resulting coefficient is actually the elasticity of the impact of an unexpected exchange rate change on corporate stock returns, rather than the true exposure, which by definition should be some quantity of foreign currency, but this elasticity is commonly referred to in the literature as the exposure.³ In a seminal study of the exchange rate exposure phenomenon, Jorion (1990) investigates the effect of exchange rate risk on the return of 287 U.S. multinational firms based on a market model augmented with a multilateral exchange rate index, as suggested by Adler and Dumas (1984):

$$R_{jt} = \alpha_j + \beta_j R_{Mt} + \delta_i R_{FXt} + \varepsilon_{jt}, \quad (1)$$

³ Note that only unexpected exchange rate changes give rise to exchange rate risk as prices reflect current market expectations (see e.g. Bartram et al., 2005). Few studies, such as Choi and Prasad (1995), do not use the simple change in exchange rates, but calculate unexpected exchange rate changes as the difference between actual and expected exchange rates, where expected exchange rates are the forward rate or based on lagged spot rates.

with R_{jt} , R_{Mt} and R_{FXt} denoting the stock return, the return on the market index and the change in the exchange rate variable (index), respectively.

Despite these firms being selected due to significant international activities, Jorion finds that only 15 firms or 5.2% of the sample have a significant exchange rate exposure at the 5% significance level – only little more than by pure chance. In another early study of the exposure of U.S. firms using the same basic technique, Amihud (1994) fails to find any significant contemporaneous exposure for a sample of the 32 companies that made all of Fortune magazine’s “50 Leading Exporters” list from 1982–1988. In the first multi-country study on exposure, Bodnar and Gentry (1993) use the same methodology as above and find not just a low percentage of industry portfolios with significant exposures (at the 5% level) in the United States (23%), but also in the much more internationally open and export-oriented countries of Canada (21%), and Japan (25%). These early exposure results triggered a set of empirical studies to examine the exposure puzzle based on different empirical designs, but they largely find similar results.

The most important exposure studies with large samples are summarized in Table 1, but to illustrate the nature of the results we point to some important examples. Within the United States, Choi and Prasad (1995) find significant exchange rate exposure to a trade-weighted (TW) value of the U.S. Dollar for just 14.9% and 10% of U.S. multinationals (at the 10% level) based on individual firms and industry portfolios, respectively. Similarly, Dukas et al. (1996) never find more than 10% of firms with significant exposure (at the 5% level) to any exchange rate index over any time period.

Results are similar in studies outside the United States. To illustrate, Loudon (1993a) studies 141 Australian firms and finds that only 10.6% exhibit a significant exposure to the foreign currency value of the Australian Dollar, although this proportion increases to 30% when

using industry portfolios (Loudon, 1993b). He and Ng (1998) examine 171 Japanese multinationals and find a more substantial, but still surprisingly low 26.3% of the firms with significant exchange rate exposure to a multilateral exchange rate index over the period 1979–1993.⁴ In Germany, Bartram (2004) finds that 7.5% of the 373 nonfinancial firms he studies have a significant (5% level) exposure to a trade-weighted exchange rate index. Nydahl (1999) studies 47 Swedish firms between 1992 and 1997 and documents significant exchange rate exposures for 17.0% of the sample. Dominguez and Tesar (2001a) study exchange rate exposure at the firm and industry level in several open, developed and developing countries. They find the following percentages of firms that are exposed to either a trade-weighted exchange rate, the U.S. dollar, or any additional exchange rate: 14% (Chile), 19% (France), 21% (Germany), 26% (Italy), 31% (Japan), 26% (Netherlands), 21% (Thailand), and 19% (United Kingdom). Priestley and Ødegaard (2005) investigate 7 non-finance industries in Norway and find that none of them are significantly exposed to the U.S. dollar and the ECU using the standard regression model.

Several studies examine firms across many countries. To illustrate, Bartram and Karolyi (2006) study the exposure of a large sample of nonfinancial firms in 18 European countries, the United States and Japan and find only small exposures of firms in these countries vis-à-vis trade-weighted exchange rate indices. Doidge et al. (2006) provide a comprehensive global analysis of the exchange rate exposure of over 17,929 firms from countries in Europe, Asia and North America. Even in this universe of firms around the world, only 8.2% show a significant exposure coefficient at the 5% level. Overall, this evidence suggests that if anything exchange rate exposure may be marginally larger in more open, export-oriented economies (where the market index as a whole is typically also more sensitive to exchange rate movements), but generally conforms

⁴ They also find that keiretsu multinationals are more exposed to exchange-rate risk than nonkeiretsu firms.

with Griffin and Stulz (2001), who perform a cross-country industry analysis and conclude that the foreign exchange rate exposure is economically and statistically small.

The studies listed in Table 1 also nicely summarize the variety of methodological variations that have been taken to try to resolve the perceived puzzle of the low prevalence of significant exposures. These include the issues of the choice of the exchange rate variable and the control variables, the allowance for a lag in the exchange rate-return relation, allowing for time variation of the exposure estimates, changes in the return horizons used to measure the exposures, as well as the possibility of nonlinearities in the exposures.

The majority of the early exposure studies use a trade-weighted multilateral exchange rate. However, it can be argued that this exchange rate is not representative for individual firms and can lead to diversification effects across currencies, thus reducing the significance of the empirical exposure estimates. As a result, several studies use bilateral exchange rates to investigate the impact of the choice of the exchange rate variable on the results. However, this modification does little to change the prevalence of significant exposures among nonfinancial firms. Representative among these is a study by Khoo (1994), in which the percentage of Australian mining companies with significant exposures to individual exchange rates remains low: 8.2% for the U.S. Dollar, 12.2% for the South African Rand, 6.3% for the Japanese Yen, 17.8% for the British Pound, 4.3% for the German Mark, and 14.3% for the Mexican Peso. Miller and Reuer (1998a) also fail to find the use of bilateral rates improve the measurement of exposure. In looking at exposure to the Canadian Dollar, German Mark, Japanese Yen, Mexican Peso, Hong Kong Dollar and Korean Won, they do not find more than 15% of the firms with significant exposure to these currencies. Bartram (2004) is a natural experiment with respect to this issue in that he uses both bilateral and multilateral exchange rates. While the results using the bilateral

DEM/USD rate provide a greater percentage of significant exposures (7.8% for $\% \Delta \text{USD}$ versus 7.5% for $\% \Delta \text{TW}$), the difference is economically irrelevant with respect to solving the exposure puzzle.

Another issue consists of the choice of control variables for the exposure regression. Most studies have departed from the original Adler and Dumas (1984) model and include control variables, such as the return to a market index or APT factors, in the empirical specification for measuring exchange rate exposure. Such control variables can be useful in reducing the standard error of the regression and improving the precision of the exposure estimates. It also ensures that the exchange rate exposure estimate captures only those influences of the exchange rate movements that are not correlated with the control variables. At the same time, it must be recognized that the use of control variables makes the exposure estimates “residual exposures” rather than “total exposures” that arise from the regression without control variables. This difference in research design can result in significant differences in the distribution and resulting interpretations of the sign, size, and significance of the firms' exposure estimates depending on the correlation of the control variables with the exchange rate (Bodnar and Wong, 2003).⁵

Naturally, studies that use exchange rate variables as the only explanatory variable of stock returns or orthogonalize the market index yield higher significance for exchange rate exposures, because in this setting the exchange rate variable picks up additional effects that may be correlated with exchange rates, but that can hardly be interpreted economically as exchange rate risk. To illustrate, Booth and Rotenberg (1990) find a significant USD exposure for 67.3% of the

⁵ In particular for the United States, exposure differences exist across alternative definitions of the market portfolio as a control variable due to a size - exposure relation for U.S. firms. This effect arises because of differences in the correlations of alternative market portfolios with the exchange rate due to differences in the weighting (value vs. equal) of large firms that tend to be more positively exposed to home currency depreciations.

156 analyzed firms in Canada and also for a portfolio of firms, but surprisingly the exposure coefficient is negative when theory predicts it to be positive.⁶ Similarly, Kiyamaz (2003) finds that 46.8% of the 109 firms studied are significantly affected by exchange rate risk for estimations without market index, and 61.5% show significant exchange rate exposures when using the residual market index that is orthogonal to the exchange rate variable. However, in general this practice does little to alter the situation of a lower prevalence of exchange rate exposures than expected by the motivation of the paper, and few other papers seem to choose to orthogonalize the control variables with respect to the exchange rate. Studies that orthogonalize the exchange rate variable with respect to the control variables typically do not find different results for exchange rate exposures compared to using the control variables and complete exchange rate variable (e.g. Choi and Prasad, 1995; Bodnar and Gentry, 1993).^{7,8}

In addition to contemporaneous exchange rate effects, some studies investigate potential mispricing of exchange rate effects. The examination of lagged exchange rates is justified by the fact that the exposure relation within a firm is often complex and the disclosure of company information detailing these effects typically takes place with some delay and may thus be fully reflected in stock prices only with a time lag. Moreover, the assessment of the impact of exchange

⁶ This can be explained by the fact that the Canadian and U.S. markets are highly correlated and the U.S. market generally has a positive correlation with the value of the USD (see, Bodnar and Wong, 2003).

⁷ As simple econometric theory implies, orthogonalization of the exchange rate variable with respect to the control variables results in the same exposure estimates as the regression without any orthogonalization. Orthogonalization of the control variables with respect to the exchange rate results in the same estimates of exposures as in a simple univariate regression, just with more precision on the estimates.

⁸ A related issue related to the construction of the exchange rate variable is the implied assumption that the simple change in the exchange rate is the correct variable to measure exchange rate exposure. The use of the simple change as the appropriate exchange rate variable implicitly assumes that the expectation for the future level of the exchange rate is the current exchange rate (simple random walk assumption). While this has been shown to be reasonable as a short term forecast for nominal exchange rates, it is likely to be less appropriate for real exchange rates, especially if the market maintains an assumption of long run mean reversion of the relevant real exchange rate towards some equilibrium level (say a Purchasing Power Parity level).

rate risk is a highly complex issue, since market participants have to distinguish between temporary and permanent exchange rate effects. By the same token, appreciations and depreciations possibly have different, asymmetric effects on stock prices, the impact of several currencies needs to be assessed simultaneously and only incomplete information on corporate hedging is available to investors. Amihud (1994) detects some evidence of lagged exposures in his study of the largest U.S. exporters, both at monthly and quarterly horizons. Bartov and Bodnar (1994) find significance for lagged exchange rate variables for a selected sample of U.S. firms. Bartov and Bodnar (1995) relate the lagged exposure to the choice of accounting methodologies and document it diminishing over time. Several other studies (Donnelly and Sheehy, 1996; Walsh, 1994) find only weak significance for lagged exchange rates and, in contrast, most others considering this possibility find no significant lag variables and are thus in line with the market efficiency hypothesis (e.g. Amihud, 1994).

Another potential explanation of low significance of exchange rate exposures that previous research has considered is time variation of the exposure. Indeed, in most studies that consider subperiod analysis, the exposure coefficients and their significance vary noticeably across subperiods (Brunner et al., 2000). The interesting question is whether this time variation is driven by economic factors or simply estimation error. Allayannis (1997) directly studies this phenomenon by modeling conditional exposure as a function of economic factors. He documents a significant relationship between the exchange rate exposure of industry portfolios of U.S. manufacturing firms and the industry export/import ratios; however, the explanatory power of this predicted time variation in exposure is small and cannot explain the lack of statistical significance for the standard unconditional exposure estimates. By the same token, Allayannis and Ihrig (2001) document that the exposure of nonfinancial firms varies with industry markups,

while Bodnar et al. (2002) relate exposure to pass-through. Similarly, the time-variation of the exchange rate exposure of firms in the automotive industry is consistent with changes in the competitive environment within the industry, i.e. market share (Williamson, 2001).

Other studies look at the effect that different time horizons for the return calculation have on the significance of exposures (Bodnar and Wong, 2003; Chow et al., 1997a, 1997b). The results of these studies suggest that the percentage of significant exposures rise as the return horizon lengthens. While the change is relatively minor for return horizons of up to 24 months, the effect becomes very noticeable at long horizons of 36 – 60 months as the percentage of firms with significant exposures often rises to more than 50%. Nevertheless, the increase of exposures with horizon is likely due to the fact that the exchange rate changes (in real terms in these studies) tend to mean revert towards zero with time due to purchasing power parity, while the real equity returns they are attempting to explain theoretically grow linearly with time. These results suggest that noise in short horizon returns is probably a contributing factor for the low prevalence of significant exposures in the literature, but estimating exposure at very long return horizons is not always a feasible option.⁹

Yet another explanation of low significance of exchange rate exposures consists of the observation that the traditional approach to estimate exposures only assesses the linear exposure component, but does not consider nonlinear or asymmetric exchange rate exposures (Bartram, 2004; Bartram, 1999). In fact, financial theory suggests that the exposure may be in part nonlinear due to corporate cash flows being a nonlinear function of exchange rates. While several studies investigate nonlinear and asymmetric features of exchange rate exposures (Bartram, 2004;

⁹ Note that most studies use nominal data, while it would be more accurate to consider the effect of exchange rate changes on stock returns after accounting for inflation. Nevertheless, several studies use data adjusted for inflation, or both, real and nominal data, and typically find little different results in short horizons (see e.g. Bodnar and Wong, 2003; Choi and Prasad, 1995; Booth and Rothenberg, 1990).

Koutmos and Martin, 2003b; Miller and Reuer, 1998b), the evidence does not fully resolve the exposure puzzle either, as nonlinear exposures appear more significant, but still only for a limited number of firms. To illustrate, Bartram (2004) documents significant linear exposures to a trade-weighted exchange rate index (the U.S. dollar) for 7.8% (8.3%) of the sample firms in Germany as one of the most export-oriented economies in the world, while 11.5% (14.5%) exhibit a significant nonlinear exposure. Miller and Reuer (1998b) study all U.S. manufacturing firms during the period 1988-1992 and analyze exposure separately for appreciating and depreciating currency movements. They find the following fractions of firms with significant exchange rate exposure for currency appreciations (depreciations): 2.9% (2.5%) for the Canadian dollar, 8.0% (5.8%) for the Japanese yen, and 9.1% (5.0%) for the Mexican peso. This evidence indicates some, but limited evidence for nonlinear/asymmetric exposures that is marginally more significant than the linear exposure component.

3 An Alternative Explanation for the Exposure Puzzle

Given the difficulty of the variations in methodological approaches in raising the percentage of significant exposures to a level consistent with researchers' priors, we consider the possibility that these priors are the source of the puzzle. This explanation for the low observed significance of the sensitivity of stock prices to exchange rate movements begins with the argument that a high degree of financial price volatility can be associated with lower firm valuations as it reduces the expected value of future cash flows in a world with market imperfections (Rawls and Smithson, 1990). In particular, several theories have been developed suggesting motives for corporate risk management due to bankruptcy costs, a convex tax schedule (Smith and Stulz, 1985), or underinvestment problems (Bessembinder, 1991; Froot, Scharfstein, and Stein, 1993). It then follows from value maximizing behavior that firms with inherently large exchange rate exposures

will be the most likely to suffer exchange rate volatility induced reductions in firm value and will therefore be the ones most likely to take actions to mitigate their exposure.¹⁰

As discussed in most textbooks on international financial management and risk management, there are two ways in which firms can mitigate the impact of exchange rate changes on their profitability (see e.g. Stulz, 2003). The first is that the firm can structure its operations so that the firm is operationally hedged against exchange rate fluctuations. The other method is the use of financial hedges to take financial positions to offset inherent exposures so that the overall profitability and reported performance of the firm is less sensitive to exchange rate movements. Most international finance textbooks argue that the first-best way for a firm to deal with exchange rate exposure is to consider the structure of their operations (see e.g. Eiteman et al., 2001). This involves considering the mix of outputs, inputs and locations of production in such a way as to minimize the net exposure to exchange rates, subject to the adjustment and operating costs of such structures. The basic idea is to try to match as best as possible the cash flows (inflows minus outflows) of the firm in each currency. For a firm with foreign currency revenues from export sales, this might entail diversifying operations to include importing operations, structuring their sourcing to make greater use of foreign currency based inputs, or in the extreme to move the production of foreign sales to foreign markets by becoming a multinational firm. By more closely matching the foreign currency inflows and outflows, firms with significant foreign operations will find their exposure fall significantly relative to standard exporting or importing operations.

¹⁰ Note, however, that recent evidence provides only mixed support for these popular theories (see e.g. Bartram et al., 2003; Géczy, Minton, and Schrand, 1997; Nance, Smith and Smithson, 1993).

Such a decline can be seen with the help of the model of exposure created by Bodnar and Marston (2000).¹¹ In this model Bodnar and Marston use perfect market assumptions and focus only on the price induced effects of exchange rate changes on the cash flows of a profit maximizing firm. From a standard model of firm value they derive an expression for the foreign currency exposure elasticity of a home currency firm, δ , as a function of just three inputs:

$$\delta = h_1 + (h_1 - h_2)((1/r) - 1) \quad (2)$$

where: h_1 = the ratio of foreign currency revenues to total revenues of the firm,

h_2 = the ratio of foreign currency costs to total costs of the firm,

r = the profit ratio of the firm, i.e. income/sales.

To compare the reduction in exposure for a firm that operationally hedges, consider the exposure from the model for an exporting firm. Assume the exporting firm produces goods locally with all local costs ($h_2 = 0$), sells 30% of its output in the export market for foreign currency revenues ($h_1 = 30\%$), and has a profit ratio of 10% ($r = 10\%$). For this firm the exposure elasticity is:

$$\delta = 0.30 + (0.30 - 0)((1 / 0.1) - 1) = 3.0.$$

The exposure for this firm is equivalent to an amount of foreign currency equal to three times its market value. This is a large and economically significant exposure, and given its signal to noise ratio this would be very likely to be a statistically significant exposure in an empirical estimation.¹²

Suppose that this firm decided to operationally hedge its exposure by either sourcing a significant percentage of its inputs from foreign currency-priced suppliers or by establishing op-

¹¹ This model is similar, though more complete than previous models e.g. by Levi (1994), Shapiro (1975) and others.

¹² The concept of the signal to noise ratio pertains to the strength of an effect (signal) relative to other contemporaneous effects (noise).

erations abroad to serve the foreign market. We shall assume that in this latter case the result is that the firm moves 30% of its costs into foreign currency, so $h_2 = 30\%$. With both h_1 and r at their previous levels, the exposure of this operationally hedged international firm becomes:

$$\delta = 0.30 + (0.30 - 0.30)((1 / 0.1) - 1) = 0.3.$$

By structuring its operations to incur foreign currency costs in a similar proportion to its foreign currency revenues, the firm reduces its exposure to an amount of foreign currency equal to less than one third of its market value. This is a reduction in exposure by a factor of nine. Thus, as this model suggests, the structuring of a firm's operations can dramatically reduce the size of its exposure elasticity, to a level much less likely to be statistically significant given the degree of noise in exchange rates and returns.

An interesting feature of this and most other models of financial exposure using firm value is that they assume no strategic response on the part of the firm in response to the new competitive environment, post exchange rate change. They assume that the firm structure remains constant and that the firm simply accepts the impact of the exchange rate change on the present value of the infinite stream of future profits. In reality, firms operationally react to exchange rate movements and actively adjust their operational structure to adapt to the new exchange rate situation by altering the production, sourcing and/or production location. If managers are making these decisions rationally, then it will be the case that the impact of an exchange rate change on the stream of future profits is less than what is predicted by these models. This suggests that the real exposure of firms is likely to be even less than predicted by models of exposure.

A caveat of the fact that firms react to exchange rate changes is that that these reactions take time to occur. Unless the firm has had the foresight to build into its operational structure the

flexibility necessary to be able to respond operationally to exchange rate changes quickly (real options), it likely will take the firm some time to make the desired operational changes. While changing suppliers may take only a quarter or two, altering the mix of outputs produced by the firm or moving the location of production may take several years. Nevertheless, the ability of the firm to make these sorts of operational changes in response to an exchange rate change dampen the market's perception of the exposure by reducing the impact of the exchange rate change on profits in the future, leaving just the impact on profits in the short-run. Therefore, operational hedging is a plausible explanation for finding lower stock price exposure than might be expected based upon the degree of international activity. While foreign operations are likely to reduce the exchange rate exposure in principle, the effect will be stronger for multinational corporations with subsidiaries spread across many countries (breadth) as opposed to a high concentration of foreign operations in a few countries (depth). Table 2 summarizes evidence on important patterns observed in the cross-section of exchange rate exposures. The existing empirical evidence suggests that corporations with greater breadth have lower exchange rate exposures, while those with greater depth are more exposed (Pantazis et al., 2001).

Consistent with this view, we note that the largest firms in any sample tend to be the multinational firms with significant operations in many countries. In empirical studies that look at exposure and firm size, it appears that larger firms tend to be associated with smaller (absolute value) estimates of exchange rate exposure elasticities (as e.g. documented in Dukas et al., 1996; Chow and Chen, 1998). These smaller exposure elasticities tend to be less likely to be statisti-

cally significant due to the inherent level of noise in both exchange rate changes and stock returns.¹³

Since these operational changes at the firm level take time to implement, the near term profitability of the firm remains exposed to exchange rate changes even for firms that are expected to adjust operations in response to exchange rate changes. Although this exposure of near term profits will be a much smaller percentage of firm value than the exposure of all future profits (the longer term profits are at least somewhat protected by the expected operational adjustments, but they are also less important in present value terms), for some firms this near term exposure remains significant due to the high time value of money of cash flows in the near future. Consequently, one would rationally expect that these firms would act to reduce this exposure through financial hedging, such as derivatives or foreign currency debt.

We know from survey evidence that firms who recognize that they have an exposure to exchange rates are active users of financial derivatives (see, e.g., Bodnar et al., 1998; Bartram et al. 2003; Bodnar et al., 2003). Another result of these surveys is that firms predominantly use financial derivatives to hedge short-term exposures, which is consistent with the fact that they use operational methods to deal with longer-term exposure. It is also plausible given that short-term exposure, e.g. resulting from foreign currency receivables or payables, are typically well known, while long-term exposures are subject to considerable uncertainty. In their survey of U.S. nonfinancial firms, Bodnar et al. (1998) find that more than 60% of firms do *all* of their currency hedging within a one-year maturity, suggesting that they are mostly hedging existing exposures, hedging for the reporting period, or hedging the short-term competitive impact of exchange rate

¹³ When measuring exposure elasticities for a set of firms/portfolios against a common exchange rate changes, it turns out that the significant exposures lie almost entirely in the extremes of the distribution (see e.g., Jorion, 1990).

changes on performance. At the same time, the cash flows from and the value changes of the derivatives portfolios of nonfinancial firms are small relative to firm's operating cash flows, suggesting that derivatives are used to fine-tune an overall risk management program that makes effective use of operational and other forms of hedging (Guay and Kothari, 2003).

It is important to note, that the empirically estimated exposure to exchange rates reflects only the net (post-hedging) exposure. Thus one would expect that the exposure of firms that use financial derivatives is also lower than what is predicted by financial models based upon operational structure alone. While this effect is difficult to study empirically as it requires controlling for the firms' pre-hedging exposure, Allayannis and Ofek (2001) show evidence that the use of financial derivatives reduces the estimated exchange rate exposure (Table 2). The empirical evidence on derivatives suggests that exchange rate derivatives usage is concentrated in firms with significant foreign operations (Bartram et al., 2003). These are the firms that researchers are expecting to reveal significant exchange rate exposure. However, if the exposure reduction for these firms from financial hedging is large enough these firms will not produce significant exposure estimates.

The implication of this line of reasoning is that the percentage of significant exchange rate exposures is smaller than anticipated not entirely because of methodological, but rather because of practical reasons. Both, firms with low underlying exposure that do not need to hedge, as well as firms with large underlying exposures that employ one or several forms of hedging, may exhibit only weak exchange rate exposures net of hedging. The result is that a small fraction of firms in any sample studied will reveal significant exchange rate exposure. In contrast, the priors that researchers have formed on the percentage of firms with significant exposures based upon measurable operational features may not fully take into account the fact that firms endoge-

nously make rational decisions to reduce these exposures through both operational and financial risk management techniques. It is precisely the most exposed firms that will be most likely to use these methods most intensively, reducing their exposure to less significant levels.

Note that it is also operationally plausible that failure to control for hedging activities is a major explanation of the exposure puzzle because data on these activities are seldom readily available and the effects are difficult to control for in empirical exposure estimations. In particular, even static operational (natural) hedging suffers from a measurement problem, as firms do not report foreign currency costs. Moreover, changes in the location of production or sourcing of inputs or the pricing and marketing of products would not appear in the financial statements, except perhaps as a brief mention in the MD&A. Similarly, the impact of financial hedging on exposures is difficult to estimate, and only in recent years disclosure and reporting requirements have changed (e.g. FASB 133 in the United States) such that information on the market value of hedge positions have become available to researchers. Prior to these regulatory changes, it had been nearly impossible to measure the impact of corporate hedging on cash flows and firm value.

Given these problems of capturing the extent of exposure mitigation activities, it remains that the firms/portfolios one finds with significant exposures fall into one of two categories: spuriously significant exposures based upon the statistical uncertainty, and firms/portfolios that have not fully hedged their true underlying exchange rate exposure, perhaps because the remaining exposure does not have a substantial negative effect on the expected market value of the firm. Fortunately, the limited number of significant exposures does not appear to be predominantly the result of spurious relations. Consistent with the latter argument and despite the arguments above, it remains the case that firms with high exchange rate exposures (even after hedging) are heavily involved in international business, typically proxied for by the percentage of foreign sales (e.g.

Jorion, 1990; Bodnar and Gentry, 1993; Choi and Prasad, 1995; Simkins and Laux, 1997; Doidge et al., 2006; Doukas et al., 2003; Bartram, 2004), foreign assets (e.g. Bodnar and Gentry, 1993; Choi and Prasad, 1995), foreign operating profit (Choi and Prasad, 1995), and trade (e.g. Bodnar and Gentry, 1993; Chow and Chen, 1998; He and Ng, 1998; Dominguez and Tesar, 2001b) (Table 2).

In addition to these and the discussed effects of operational and financial hedging on exposures, a large number of empirical studies are successful in linking the exposure estimates to further economic variables in a manner that is consistent with the predictions of financial theory, despite corporate hedging activities and the low levels of significance. To illustrate, firms with more liquidity show lower exposures (Bartram, 2004), and the exchange rate exposure is related to leverage (e.g. He and Ng, 1998; Doukas et al. 2003) and industry sectors (e.g. Jorion, 1991; Bodnar and Gentry, 1993; Bartram, 2004).

Finally, there is evidence from event studies that is in line with economic theory and intuition about the exchange rate exposure of nonfinancial firms. In particular, two major events in the last three decades represent natural laboratories for the study of exchange rate exposure, as they represent structural changes in the exchange rate risk that firms face. These events are the transition from fixed to floating exchange rates after the breakdown of the Bretton Woods system in 1973, and the introduction of the Euro in 1999 with the reverse effect.¹⁴ Bartov et al. (1996) study the first event and, consistent with the increase in exchange rate risk, document increases in the stock return volatility, market and exchange rate betas of multinational firms, while control firms show smaller or no effects. Similarly, Bartram and Karolyi (2006) document that the intro-

¹⁴ Effects found in these studies may not necessarily explain the failure to find significant exposure, but rather demonstrate that firms' exposures change in response to the macroeconomic environment in predictable ways.

duction of the Euro significantly decreased the volatility of trade-weighted exchange rates of European countries and led to concomitant decreases in market and exchange rate exposures particularly for firms with a high fraction of foreign sales or assets in Europe.

As a bottom line, exchange rate exposure may be hard to detect empirically, but this result can be explained with firms reacting rationally with operating and financial hedging to their exposures yielding only a small number of firms with statistically significant net exposure. Nevertheless, the estimated exposures are economically meaningful in that they can be related to firm characteristics in a way that is consistent with economic theory.

4 Conclusion

This paper offers a comprehensive account and analysis of the existing evidence on the exposure of nonfinancial firms to exchange rate risk. It is motivated by the fact that most studies identify a significant exchange rate exposure only for a very small number of firms, even if they have substantial international business activities, which gives rise to the exposure puzzle. Existing studies investigate the exposure phenomenon with a variety of approaches, focusing on different samples, methodologies and levels of aggregation, recently covering many countries apart from the United States. While the past decade has seen a growing body of empirical evidence on the exposure phenomenon, the main empirical result appears to be largely unchallenged: Regardless of the study characteristics, only about 10–25% of all firms studied show significant exchange rate exposures, a level that seems to be below prior expectations based upon theoretical and anecdotal predictions.

This paper suggests that the body of empirical evidence may not be unreasonable considering the fact that stock returns only reflect the exposure of firms net of corporate hedging. Non-financial firms can implement risk management not only through financial hedging (e.g. with

derivatives), which primarily reduces volatility in the near term, but also through operational hedging via the location and structure of operations and the ability to modify operations in response to currency movements, which reduces the long-term impact of exchange rate changes on firm value. Consequently, if firms react rationally to their exposures, most firms will either have no exposure to start with, or reduce their exposure to levels that may be too small to detect empirically. Consequently, the exposure puzzle may not be a problem with methodology or theory, but mainly the result of endogeneity of operative and financial hedging at the firm level.

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Table 1: Exchange Rate Exposure of Nonfinancial Corporations

The table shows the results of studies on the foreign exchange rate exposure of nonfinancial corporations. The columns list the study (authors and year), the period, the sample, the primary results (variable [Lag] (sign/significance level/percentage of significant firms or portfolios), and the study characteristics. All results are presented for exchange rates in local currency relative to foreign currency. APT = APT factors, D = dividend yield, Fx = x exchange factor from a factor analysis of exchange rates, TWx = trade-weighted exchange rate index of x currencies, I = interest rate(s), L = lagged return, M = market index, MF = market factors from factor analysis of stock returns, S = spread between long-term and short-term yield (term structure).

Study	Period	Sample	Results	Characteristics
Booth/Rotenberg (1990)	1979-83	156 firms (CAN)	%ΔUSD (- / 5 / 67.3)	monthly data no control variables
Jorion (1990)	1971-87	287 multinational firms (USA)	%ΔTW15 (± / 5 / 5.2)	monthly data
		40 multinational firms (USA)	%ΔTW15 (± / 5 / 7.5)	control variables (M)
		40 portfolios [287 multinational firms] (USA)	%ΔTW15 (± / 5 / 15.0)	monthly data control variables (M) portfolios
Jorion (1991)	1971-87	20 portfolios [NYSE firms] (USA)	%ΔTW15 (± / 5 / 20.0)	monthly data control variables (M) portfolios
			%ΔTW15 (± / 5 / 35.0)	monthly data control variables (APT) portfolios
Bodnar/Gentry (1993)	1979-88	39 portfolios [NYSE , AMEX firms] (USA)	%ΔTW6 (± / 5 / 23.1)	monthly data
		19 portfolios [TSE firms] (CAN)	%ΔTW6 (± / 5 / 21.1)	control variables (M) portfolios
	1983-88	20 portfolios [Nikkei 500 firms] (JPN)	%ΔTW6 (± / 5 / 25.0)	
Loudon (1993a)	1984-89	141 firms (AUS)	%ΔTW (± / 5 / 10.6)	monthly data control variables (M) portfolios
Loudon (1993b)	1980-91	23 indices (AUS)	%ΔTW (- / 5 / 30.4)	monthly data control variables (M) portfolios
Amihud (1994)	1979-88	3 portfolios [32 exporters] (USA)	%ΔTW15 [1] (+ / 5 / 33.3)	monthly data control variables (M, L) portfolios
		4 portfolios [32 exporters] (USA)	%ΔTW15 [2] (+ / 5 / 50.0)	quarterly data control variables (M, L) portfolios
Bartov/Bodnar (1994)	1978-90	208 firms (USA)	%ΔTW6 [1] (+ / 1 / 100)	quarterly data control variables (M) pooling abnormal stock returns
Khoo (1994)	1980-87	98 mining firms (AUS)	%ΔUSD (- / 5 / 8.2), %ΔZAR (± / 5 / 12.2), %ΔJPY (± / 5 / 6.3), %ΔGBP (+ / 5 / 17.8), %ΔDEM (± / 5 / 4.3), %ΔMXN (± / 5 / 14.3)	monthly data control variables (M)

(continued)

Table 1: Exchange Rate Exposure of Nonfinancial Corporations (continued)

Study	Period	Sample	Results	Characteristics
Levi (1994)	1970-85	1 index [TSE paper and wood index] (CAN)	%ΔGBP (- / 10 / 100), %ΔJPY (+ / 1 / 100)	monthly data control variables (I) portfolios
			%ΔGBP (- / 10 / 100), %ΔJPY (+ / 1 / 100)	monthly data control variables (M) portfolios
Walsh (1994)	1982-93	391 nonbanks (USA)	%ΔTW (± / 5 / 10.9), %ΔTW [1] (± / 5 / 5.6), %ΔTW [2] (± / 5 / 4.8)	monthly data control variables (M)
Choi/Prasad (1995)	1978-89	409 multinational firms (USA)	%ΔTW10 (± / 10 / 14.9)	monthly data control variables (M)
			%ΔTW10 (± / 10 / 14.9)	monthly data control variables (M, I)
		20 portfolios [409 multinational firms] (USA)	%ΔTW10 (+ / 10 / 10.0)	monthly data control variables (M) portfolios
			%ΔTW10 (+ / 10 / 10.0)	monthly data control variables (M, I) portfolios
Prasad/Rajan (1995)	1981-89	20 portfolios [765 NYSE firms] (USA)	%ΔTW16 (- / 5 / 15.0)	monthly data control variables (M, I) portfolios
		12 portfolios [60 firms] (DEU)	%ΔTW16 (- / 10 / 16.7)	
		25 portfolios [147 firms] (JPN)	%ΔTW16 (- / 5 / 4.0)	
		17 portfolios [89 firms] (GBR)	%ΔTW16 (- / 5 / 5.9)	
Dukas/Fatemi/Tavakkol (1996)	1986-90	1402 firms (USA)	%ΔF1 (± / 5 / 5.3), %ΔF2 (± / 5 / 5.0), %ΔF3 (± / 5 / 7.2), %ΔTW15 (± / 5 / 6.2)	monthly data control variables (2 MF)
			%ΔF1 (± / 5 / 7.5), %ΔF2 (± / 5 / 8.3), %ΔF3 (± / 5 / 6.1), %ΔTW15 (± / 5 / 7.5)	monthly data control variables (M)
Simkins/Laux (1997)	1989-93	395 firms [Fortune 500] (USA)	%ΔTW131 (± / 5 / 14.2)	monthly data control variables (M)
		25 portfolios [413 firms] (USA)	%ΔTW131 (± / 5 / 32.0)	monthly data control variables (M) portfolios
Allayannis (1997)	1978-86	137 portfolios [manufacturing firms] (USA)	%ΔTW101 (± / 5 / 29.2)	monthly data control variables (M)
	1987-90	124 portfolios [manufacturing firms] (USA)	%ΔTW101 (± / 5 / 37.1)	portfolios time-varying exposure

(continued)

Table 1: Exchange Rate Exposure of Nonfinancial Corporations (continued)

Study	Period	Sample	Results	Characteristics
Chow/Lee/Solt (1997a)	1977-89	65 portfolios (USA)	%ΔTW6 (+ / 10 / 9.2) 1-month return %ΔTW6 (+ / 10 / 13.8) 3-months return %ΔTW6 (+ / 10 / 32.3) 6-months return %ΔTW6 (+ / 10 / 64.6) 12-months return %ΔTW6 (± / 10 / 75.4) 2-years return %ΔTW6 (± / 10 / 67.7) 3-years return %ΔTW6 (± / 10 / 84.6) 4-years return	monthly data control variables (D, S) portfolios overlapping periods
Chow/Lee/Solt (1997b)	1977-91	213 multinational firms (USA)	%ΔTW6 (- / 5 / 2.3) 1-month return %ΔTW6 (± / 5 / 5.6) 3-months return %ΔTW6 (± / 5 / 12.7) 6-months return %ΔTW6 (± / 5 / 27.2) 12-months return %ΔTW6 (± / 5 / 54.5) 2-years return %ΔTW6 (± / 5 / 74.6) 3-years return %ΔTW6 (± / 5 / 81.7) 4-years return %ΔTW6 (± / 5 / 89.2) 5-years return	monthly data control variables (D, S) overlapping periods
Chow/Chen (1998)	1975-92	1110 firms (JPY)	%ΔTW14 (± / 5 / 30.1) 1-month return %ΔTW14 (± / 5 / 23.4) 3-months return %ΔTW14 (± / 5 / 35.0) 6-months return %ΔTW14 (± / 5 / 47.4) 12-months return %ΔTW14 (± / 5 / 69.8) 24-months return	monthly data control variables (D, S) overlapping periods
Dominguez (1998)	1984-95	18 industry portfolios (JPY)	%ΔUSD (± / 5 / 38.9)	weekly data control variables (M) portfolios
He/Ng (1998)	1978-93	171 multinational firms (JPN)	%ΔTW9 (± / 5 / 26.3)	monthly data control variables (M)
Miller/Reuer (1998a)	1988-92	404 manufacturing firms (USA)	%ΔJPY %ΔCAD %ΔMXN (± / 5 / 13.6) %ΔDEM %ΔKRW %ΔHKD (± / 5 / 14.6)	monthly data no control variables
	1988-92	404 manufacturing firms (USA)	%ΔJPY %ΔCAD %ΔMXN (± / 5 / 13.6) %ΔDEM %ΔKRW %ΔHKD (± / 5 / 17.3)	monthly data control variables (M, I)
Brunner/Glaum/Himmel (2000)	1974-97	71 firms (DEU)	%ΔUSD (± / 5 / 55)	daily data no control variables
			%ΔUSD (+ / 5 / 31)	daily data control variables (M)
Allayannis/Ihrig (2001)	1979-95	82 industry portfolios (USA)	%ΔTW (± / 5 / 22.2)	monthly data control variables (M)

(continued)

Table 1: Exchange Rate Exposure of Nonfinancial Corporations (continued)

Study	Period	Sample	Results	Characteristics
Griffin/Stulz (2001)	1975-97	58 industry indices (JPN)	%ΔUSD (± / 5 / 65.5)	weekly data control variables (M) portfolios
Pantzalis/Simkins/Laux (2001)	1989-93	220 multinational firms (USA)	%ΔTW (± / 5 / 15.0)	monthly data control variables (M)
Bodnar/Wong (2003)	1977-96	910 firms (USA)	%ΔTW (- / 5 / 14.6) 1-month return %ΔTW (± / 5 / 27.3) 3-months return %ΔTW (± / 5 / 21.4) 6-months return %ΔTW (± / 5 / 14.8) 9-months return %ΔTW (± / 5 / 14.4) 12-months return %ΔTW (± / 5 / 16.1) 18-months return %ΔTW (± / 5 / 23.5) 2-years return %ΔTW (± / 5 / 32.3) 3-years return %ΔTW (± / 5 / 43.8) 4-years return %ΔTW (± / 5 / 52.5) 5-years return	monthly data no control variables overlapping periods
			%ΔTW (- / 5 / 22.5) 1-month return %ΔTW (± / 5 / 31.2) 3-months return %ΔTW (± / 5 / 24.3) 6-months return %ΔTW (± / 5 / 23.5) 9-months return %ΔTW (± / 5 / 23.5) 12-months return %ΔTW (± / 5 / 23.9) 18-months return %ΔTW (± / 5 / 29.5) 2-years return %ΔTW (± / 5 / 43.6) 3-years return %ΔTW (± / 5 / 54.5) 4-years return %ΔTW (± / 5 / 61.1) 5-years return	monthly data control variables (M) overlapping periods
Doukas/Hall/Lang (2003)	1975-95	1,079 firms (JPN)	%ΔTW (± / 5 / 14.1) %ΔUSD (± / 5 / 14.3)	monthly data control variables (APT) orthogonalization
Bartram (2004)	1991-95	373 nonfinancial corporations (DEU)	%ΔTW18 (± / 5 / 7.5) %ΔUSD (± / 5 / 7.8) %ΔTW18 (± / 5 / 7.8), %ΔTW18 ³ (± / 5 / 11.5) %ΔUSD (± / 5 / 8.3), %ΔUSD ³ (± / 5 / 14.5)	monthly data control variables (M)
Bartram/Karolyi (2006)	1990-2001	701 multinational firms (18 European countries, USA, JPN)	%ΔTW (± / 5 / 9.9)	weekly data control variables (M)
Doidge/Griffin/Williamson (2006)	1975-99	17,929 nonfinancial firms (18 countries)	%ΔTW (± / 5 / 8.2)	monthly data control variables (M)

Table 2: Determinants of the Exchange Rate Exposure of Nonfinancial Corporations

The table shows the results of studies on the determinants of the foreign exchange rate exposure of nonfinancial corporations. The columns list the study (authors and year), the period, the sample, the primary results (variable (sign/significance level)), and the study characteristics. D = dividend yield, I = interest rate(s), M = market index, S = spread between long-term and short-term yield (term structure).

Study	Period	Sample	Determinants	Characteristics
Booth/Rotenberg (1990)	1979-83	156 firms (CAN)	dummy for basic industry (- / 5) foreign listing (- / 10)	monthly data no control variables
Jorion (1990)	1971-87	40 portfolios [287 multinational firms] (USA)	foreign sales/total sales (+ / 5)	monthly data control variables (M) portfolios
Bodnar/Gentry (1993)	1979-88	39 portfolios [NYSE and AMEX firms] (USA) 19 portfolios [TSE firms] (CAN)	inputs with world market price (+ / 1) foreign assets/market value (+ / 1) non-tradable goods (- / 1) exports (+ / 5) imports (- / 1)	monthly data control variables (M) portfolios
	1983-88	20 portfolios [Nikkei 500 firms] (JPN)	non-tradable goods (- / 1) exports (+ / 5) foreign assets/market value (+ / 10)	
Choi/Prasad (1995)	1985-89	61 multinational firms (USA)	foreign sales (+ / 5) foreign assets (+ / 5) foreign operating profit (+ / 10)	monthly data control variables (M)
Dukas/Fatemi/Tavakkol (1996)	1976-80	1620 firms (USA)	ln (market value) (- / 1)	monthly data
	1981-85	1615 firms (USA)	ln (market value) (- / 1)	control variables (M)
	1986-90	1402 firms (USA)	ln (market value) (- / 1)	
Simkins/Laux (1997)	1989-93	395 firms [Fortune 500] (USA)	foreign sales/total sales (+ / 1) ln (total assets) (+ / 1) industrial diversification (+ / 10)	monthly data control variables (M)
Chow/Lee/Solt (1997b)	1977-91	213 multinational firms (USA)	ln (total assets) (+ / 1) ln (market value) (+ / 1)	control variables (D, S) portfolios, overlapping periods
Miller/Reuer (1998a)	1988-92	404 manufacturing firms (USA)	foreign assets/total assets (- / 5)	monthly data no control variables
			foreign assets/ total assets (- / 5)	monthly data control variables (M, I)
Chow/Chen (1998)	1975-92	1110 firms (JPY)	leverage (- / 1) ln (market value) (- / 1) dividend yield (- / 1) exports (+ / 1) non-tradable goods (- / 1)	monthly data control variables (D, S) overlapping periods
He/Ng (1998)	1978-93	171 multinational firms (JPN)	exports (+ / 5) payout ratio (- / 5) quick ratio (+ / 5) leverage (- / 5) book-to-market (+ / 5) ln (market value) (+ / 5)	monthly data control variables (M)

(continued)

Table 2: Determinants of the Exchange Rate Exposure of Nonfinancial Corporations (continued)

Study	Period	Sample	Determinants	Characteristics
Allayannis/Ofek (2001)	1991-95	174 nonbanks [S&P 500 firms] (USA)	foreign sales/total sales (+ / 5) value of currency derivatives/total assets (- / 5)	monthly data control variables (M)
Pantzalis/Simkins/Laux (2001)	1989-93	220 multinational firms (USA)	foreign sales/total sales (+ / 1) ln (high-to-low stock price) (+ / 1) ln (# foreign countries) (- / 1) largest two # subs / total # subs (+ / 1)	monthly data control variables (M)
Doukas/Hall/Lang (2003)	1975-85 1985-95	603 firms (JPN)	foreign sales/total sales (+ / 1) debt/total assets (- / 5)	monthly data control variables (APT) orthogonalization
Bartram (2004)	1991-95	373 nonfinancial corporations (DEU)	firm liquidity (- / 1) industry dummies (\pm / 5) foreign sales/total sales (+ / 5)	monthly data control variables (M)
Doidge/Griffin/Williamson (2006)	1975-99	17,929 nonfinancial firms (18 countries)	ln (market value) (+ / 1) foreign sales/total sales (+ / 1)	monthly data control variables (M)