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# Exchange rate exposure

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**Abstract**

In this paper we examine the relationship between exchange rate movements and firm value. We estimate the exchange rate exposure of publicly listed firms in a sample of eight (non-US) industrialized and emerging markets. We find that exchange rate movements do matter for a significant fraction of firms, though which firms are affected and the direction of exposure depends on the specific exchange rate and varies over time, suggesting that firms dynamically adjust their behavior in response to exchange rate risk. Exposure is correlated with firm size, multinational status, foreign sales, international assets, and competitiveness and trade at the industry level.


*Keywords:* Firm- and industry-level exposure; Exchange rate risk; Pass-through

*JEL classification:* F23; F31; G15

## 1. Introduction

It is widely believed that changes in exchange rates have important implications for financial decision-making and for the profitability of firms. One of the central

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motivations for the creation of the euro was to eliminate exchange rate risk to enable European firms to operate free from the uncertainties of changes in relative prices resulting from exchange rate movements. At the macro level, there is evidence that the creation of such currency unions results in a dramatic increase in bilateral trade (Frankel and Rose, 2002). But do changes in exchange rates have measurable effects on firms? The existing literature on the relationship between international stock prices (at the industry or firm level) and exchange rates finds only weak evidence of systematic exchange rate exposure (see Doidge et al., 2003; Griffin and Stulz, 2001 for two recent studies). This is particularly true in studies of US firm share values and exchange rates.[2]

The first objective of this paper is to document the extent of exchange rate exposure in a sample of eight (non-US) industrialized and developing countries over a relatively long time span (1980–1999) and over a broad sample of firms. We follow the literature in defining exchange rate exposure as a statistically significant (ex post) relationship between excess returns at the firm- or industry-level and foreign exchange returns. A key result from our analysis is the finding that exchange rate exposure matters for non-US firms. We find that for five of the eight countries in our sample over 20% of firms are exposed to weekly exchange rate movements and exposure at the industry level is generally much higher, with over 40% of industries exposed in Germany, Japan, the Netherlands and the UK.[3] We find that there is considerable heterogeneity in the extent of exposure across our sample of countries as well as large variation in the direction and magnitude of exposure. Our analysis suggests that exchange rate movements do matter for a significant fraction of firms, although which firms are affected and the direction of exposure depends on the specific exchange rate and varies over time.

Having established that there is a statistically significant relationship between profitability (as measured by stock returns) and the exchange rate, the second objective of the paper is to try to explain why some firms are exposed and others are not. We use the exposure coefficients estimated in the first part of the paper in a set of second-stage regressions to test three hypotheses about the factors that could explain exposure. The first hypothesis is that firm characteristics, namely firm size and its industry affiliation, are correlated with exposure. We find no evidence that exposure is concentrated in a particular sector, but we do find that small-, rather than large- and medium-sized firms, are more likely to be exposed. One rationale for this finding could be that larger firms have more access to mechanisms for hedging exposure than small firms, although data limitations do not allow us to test this conjecture directly.

Our second hypothesis is that firms engaged in international activities are more likely to be directly affected by changes in exchange rates. We conjecture that

[2] In a sample of US multinational corporations (which are assumed to be the firms most likely to be exposed) over the period 1971–1987 Jorion (1990) found that only 15 of 287 (5%) had significant exchange rate exposure. Amihud (1994) found no evidence of significant exchange rate exposure for a sample of the 32 largest US exporting firms over the period 1982–1988.

[3] Bodnar and Gentry (1993) test for exchange rate exposure at the industry level in the US, Japan and Canada. They find significant exposure in 11 of 39 US industries (28%) over the period 1979–1988.

multinational firms, firms with extensive foreign sales and firms with holdings of international assets are more likely to be exposed to exchange rate movements, and that they are likely to benefit from a depreciation of their home currency. In France, Germany, Japan and the UK we find evidence that measures of a firm's international activities are linked to exposure and the coefficient on the direction of exposure is indeed positive.

Our third hypothesis is that firms engaged in trade are more likely to face exchange rate risk. Here, the direction of the exposure is more complicated. Exporting firms may benefit from a depreciation of the local currency if its products subsequently become more affordable to foreign consumers. On the other hand, firms that rely on imported intermediate products may see their profits shrink as a consequence of increasing costs of production due to a depreciating currency. One might expect, then, to find a correlation between exposure (positive or negative) and a firm's engagement in international markets. Lacking firm-level data on exports and imports, we use a number of proxies for a firm's relationship with international markets to test this hypothesis. We group firms into traded and nontraded sectoral categories to see if exposure is more concentrated in firms in the traded sector. Finally, we use data on bilateral trade flows at the industry level to examine the link between firm-level returns and bilateral, industry-level trade flows.

Even firms that do no international business directly, however, could be affected by the exchange rate through competition with foreign firms. For example, if Ford Motor Company were to sell no cars abroad nor import any foreign auto parts, domestic automobile sales would still be affected if the dollar price of competing Japanese automobile imports falls or rises. We posit that exposure could depend on the competitiveness of a particular industry—in less competitive industries, prices are set farther from marginal cost implying higher mark-ups. In such industries firms will have some ability to absorb exchange rate changes by adjusting profit margins and lowering "pass through". In more competitive industries we might expect close to perfect pass-through and therefore larger effects of exchange rate movements on stock returns.[4] To test this hypothesis we examine the link between firm-level exposure and two OECD measures of market concentration, a Herfindahl index and a mark-up index.

On a country-by-country basis we find only weak evidence that measures of trade and the degree of competitiveness of a particular industry are linked to firm-level exposure. Note that all of our measures used to test this hypothesis are industry-level indicators. It could be that there is sufficient heterogeneity in the trading patterns of firms within an industry that our industry-level variables simply do not reflect the impact of trade at the firm level. In our cross-country regressions, we find the industry-level export and import variables enter significantly and are correctly signed, suggesting that the additional

[4] Bodnar et al. (2002) and Marston (2001) develop a framework for analyzing the joint phenomena of pass-through and exposure. Nucci and Pozzolo (2001) examine the impact of exchange rate fluctuations on investment in a sample of Italian manufacturing firms and find a link between monopoly power and the impact of exchange rate effects. Allayannis and Ihrig (2000), Campa and Goldberg (1995, 1999) and Dekle (2000) also find a relationship between market structure and exposure.

variation in the cross-country trade data helps us better identify exposed firms. We also find that the Herfindahl index enters significantly in the cross-country regression; however, the sign on the coefficient indicates that firms in more concentrated industries are more exposed.[5]

Taken as a whole, our findings suggest that a significant fraction of firms are exposed to exchange rate risk in our sample of countries, but which firms are exposed changes over time. We do find a link between international activity and exposure, but for the vast majority of firms we are unable to identify the factors that account for their exposure. At first pass, this would seem to be a puzzling finding. If exchange rate movements matter for firms, why is it so difficult to identify the determinants of that exposure? On deeper reflection, however, it is not clear that there is a puzzle after all. Exchange rate exposure, as measured by the co-movement between exchange rates and excess returns, incorporates the effects of any hedging activity undertaken by the firm. Firms may use financial derivatives to help insure against exchange rate risk, or they may manage risk operationally by importing intermediate inputs from a number of suppliers, or by selling to an internationally-diversified consumer market.[6] Indeed the finding that the subset of firms exposed to exchange rate movements is not stable over time is likely an indication that firms dynamically adjust their behavior in response to exchange rate risk. Viewed from this perspective, it would perhaps have been more puzzling to have identified a set of firms whose profits were consistently affected by movements of a particular exchange rate over a long span of time.[7]

The paper is organized as follows. The definition of exchange rate exposure is covered in Section 2 and Section 3 describes our dataset. The benchmark exposure results and the robustness of these results are discussed in Section 4. The second-stage results on the links between exchange rate exposure and other factors are reported in Section 5. Section 6 concludes.

## 2. Defining exchange rate exposure

We follow the extensive literature on foreign exchange rate exposure by defining exposure as the relationship between excess returns and the change in the exchange rate

[5] A positive coefficient on the Herfindahl index is puzzling because we would expect firms in less competitive industries to have lower exchange rate pass through. It may be, however, that the Herfindahl index in this context is picking up the small firm size effect. Recall that our Herfindahl indices are only available at the industry level. It may be that industries with high Herfindahl indices are made up of a few large firms and a number of smaller firms. Our coding assigns the same Herfindahl index to both sets of firms (in the same industry), suggesting that our positive coefficient may be driven by the small (competitive) firms assigned to high Herfindahls.

[6] Bodnar and Marston (2001) find that foreign exchange exposure is low for a sample of 103 US firms that answered their survey of derivative usage. On the other hand, survey results reported in Loderer and Pichler (2000) suggest that Swiss firms do not seem to know the extent of their cash-flow exposure to exchange rate risk. And, based on surveys, Bodnar et al. (1998) find that firms do not seem to use derivatives to hedge exchange rate risk and in many instances, appear to use derivatives to take open positions with respect to the exchange rate.

[7] To be clear, persistent ex post exchange rate exposure should not be interpreted as evidence against market efficiency because idiosyncratic exchange rate risk could still be diversified away by individual investors.

(Adler and Dumas, 1984). More formally, we measure exposure as the value of $\beta_{2,i}$ resulting from the following two-factor regression specification:

$$R_{i,t} = \beta_{0,i} + \beta_{1,i} R_{m,t} + \beta_{2,i} \Delta s_t + \varepsilon_{i,t} \quad (1)$$

where $R_{i,t}$ is the return on firm $i$ at time $t$, $R_{\mathrm{m},t}$ is the return on the market portfolio, $\beta_{1,i}$ is the firm's market beta and $\Delta s_t$ is the change in the relevant exchange rate. Under this definition, the coefficient $\beta_{2,i}$ reflects the change in returns that can be explained by movements in the exchange rate after conditioning on the market return. Exposure in this context is defined as marginal in the sense that each firm's exposure is measured relative to the market average.[8]

Note that a literal interpretation of the CAPM suggests that in equilibrium, only market risk should be relevant to a firm's asset price, and therefore only changes in the market return should be systematically related to firm returns ($R_{i,t}$). If the CAPM were the true model for asset pricing, the coefficient on the change in the exchange rate, $\beta_{2,i}$, should be equal to zero and evidence that $\beta_{2,i}$ is non-zero could be interpreted as evidence against the joint hypothesis that the CAPM holds (i.e. the market efficiently prices systematic risk) and that exchange rate risk is unimportant for stock returns. In this paper, we are not interested in testing a specific version of the CAPM, nor are we testing whether exchange rate risk is "priced". Our approach is to use the market model (Eq. (1)) as a framework for isolating the relationship between excess returns and exchange rates in a cross-section of firms. In the second stage of our analysis (Section 5), we will try to link the estimated exchange rate "betas" with a set of factors that could proxy for plausible channels for exposure.

## 3. The data set

Our dataset includes firm-, industry- and market-level returns and exchange rates for a sample of eight countries including Chile, France, Germany, Italy, Japan, the Netherlands, Thailand and the United Kingdom over the 1980–1999 period. The specific countries in our sample were chosen both on the basis of data availability and to include in our sample both OECD and developing countries. Returns are weekly (observations are sampled on Wednesdays) and are taken from Datastream. For countries with a large number of publicly traded firms (in our sample these include Germany, Japan and the United Kingdom) we select a representative sample of firms (25% of the population) based on market capitalization and industry affiliation. For the remaining countries we include the population of firms. Table 1 provides summary information on the degree of data coverage across the eight countries. Our sample includes 2387 firms. On average the sample includes 300 firms for each country; the

[8] An alternative approach is to measure *total* exposure, or the unconditional correlation of exchange rates and returns. The advantage of *total* exposure is that it allows one to measure the exposure of all firms as a group, rather than individual firms relative to the country average. The disadvantage of *total* exposure is that it does not allow one to distinguish between the direct effects of exchange rate changes and the effects of macroeconomic shocks that simultaneously affect firm value and exchange rates.

Table 1
Data coverage

| | Chile | France | Germany | Italy | Japan | Neth | Thailand | UK |
|---|---|---|---|---|---|---|---|---|
| 1. Coverage of population of firms | | | | | | | | |
| # of firms in sample | 199 | 228 | 204 | 278 | 488 | 213 | 389 | 388 |
| # of firms in population | 225 | 228 | 897 | 301 | 1942 | 248 | 409 | 1550 |
| % coverage | 88.4 | 100 | 22.7 | 92.4 | 25.1 | 85.9 | 95.1 | 25 |
| 2. Coverage of industries | | | | | | | | |
| # of industry indices | 23 | 36 | 34 | 31 | 36 | 29 | 20 | 39 |
| % coverage | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 3. Multinational status | | | | | | | | |
| # of MNCs in our sample | 0 | 33 | 27 | 21 | 64 | 16 | 0 | 47 |
| % of firms | 0 | 14.5 | 13.2 | 7.6 | 13.1 | 7.5 | 0 | 12.1 |
| 4. Trade data | | | | | | | | |
| Industry-level bilateral trade | yes | yes | yes | yes | yes | yes | yes | yes |
| Trade concentration shares | no | no | no | no | yes | no | no | yes |
| 5. Market concentration indices | | | | | | | | |
| Industry-level Herfindahl index | no | yes | yes | no | yes | no | no | yes |
| Industry-level Mark-up index | no | yes | yes | yes | yes | yes | no | yes |
| 6. International asset data | | | | | | | | |
| % of firms reporting during 1996–1999 | 12.1 | 21.9 | 9.8 | 25.9 | 69.5 | 17.8 | 53.2 | 70.1 |
| % of firms reporting non-zero values | 0 | 6 | 9.8 | 0.4 | 26.2 | 9.4 | 3.9 | 36.6 |
| 7. Foreign sales data | | | | | | | | |
| % of firms reporting during 1996–1999 | 13.6 | 53.5 | 58.8 | 70.1 | 75.2 | 59.6 | 54.8 | 76 |
| % of firms reporting non-zero values | 3 | 39.4 | 39.2 | 49.3 | 33.8 | 53.1 | 5.9 | 46.1 |

Firm- and industry-level returns are Wednesday returns from Datastream in local currencies. Firms are sampled based on industry affiliation and firm size. Industry returns are at the 4-digit level. Multinational status is based on inclusion in (1) Worldwide Branch Locations of Multinationals (1994), (2) Directory of Multinationals (1998), or (3) the Financial Times Multinationals Index. Industry-level bilateral trade data are from Feenstra (2000). Market concentration data are OECD Secretariat calculations for 1990. Trade concentration shares are from Campa and Goldberg (1997). International asset and foreign sales data are annual averages over the period 1996–1999 from Worldscope.

largest fraction of firms in the total sample are Japanese firms (20%), and the smallest fraction are Chilean (8%). Firms with fewer than 6 months of data during the period 1980–1999 were excluded from our sample.

In Section 5 of the paper, we attempt to link our estimates of exposure to variables such as industry affiliation, firm size, a firm's multinational status, information on trade, industry-level market concentration and a firm's holdings of international assets and its foreign sales. Parts 2 through 6 of Table 1 provide information about the coverage of these variables. Datastream provides industry-level returns at a fairly disaggregated level (we focus on the 4-digit level). As shown in the second part of Table 1, there are between 23 and 39 industry categories across our sample of countries. (The list of industries is provided in Appendix Table A1).

Information about multinational status comes from three sources. The first source is Worldwide Branch Locations of Multinationals (1994), which includes a sample of 500 companies that have foreign branches. The second source, The Directory of Multinationals (1998), includes the 500 largest firms with consolidated sales in excess of $US 1 billion and overseas sales in excess of $US 500 million in 1996. Our third source of multinational information comes from the Financial Times Multinational Index (created in 2000). If a

firm appeared as a multinational in any of the three sources, we coded that firm as a multinational.

We draw on two sources to gather information about trade, both of which provide data only at the industry level. The first is Feenstra's (2000) database on world bilateral trade flows over the 1980–1997 period. This data source allows us to identify each country's major bilateral trading partners by industry. As shown in part 4 of Table 1, the Feenstra database covers all of the countries in our sample, although it does not cover all of the industry categories available from Datastream. The second source of trade information is the export, import and net input shares in manufacturing industries reported by Campa and Goldberg (1997). Their study covers two of the countries in our sample, Japan and the United Kingdom.

We are able to test whether exposure is related to industry level market structure using two measures of market concentration, both based on OECD data. The Herfindahl index, commonly used to rank the competitiveness of industries, is calculated as the sum of the squares of the market shares of all firms in an industry (these are OECD Secretariat calculations for 1990 based on the STAN database). Our second measure of industry structure is a mark-up index estimated by Oliveira Martins et al. (1996) based on the method suggested by Roeger (1995). As shown in part 5 of Table 1, the mark-up measure is available for all the countries in our sample except Chile and Thailand and the Herfindahl index is also unavailable for Italy and the Netherlands.

While Datastream provides information about industry affiliation and market capitalization for all firms in our dataset, the coverage ratios for international asset and foreign sales[9] data (available through Worldscope) is more limited. In the regression analysis below we use annual values of foreign sales and international assets averaged over the period 1996–1999. As shown in parts 6 and 7 of Table 1, the number of firms that report international assets and/or foreign sales varies considerably from country to country. Over 50% of Japanese and UK firms provide these data, while only 3% of Chilean firms (the country with the lowest coverage) provided non-zero foreign sales data and no Chilean firms provided non-zero international asset data. Worldscope codes firms that do not provide international asset or foreign sales data in two ways, with either a missing value code or a zero. Unfortunately the decision about whether to code a firm without data as missing or with a zero is apparently arbitrary. Firms that do provide information, however, also may genuinely have no foreign sales or international assets. This means that both a zero and a missing value code provide ambiguous information. If one looks only at those firms that report non-zero, and therefore unambiguous information, about foreign sales and international assets, the percent of the sample reporting drops dramatically, especially for international assets. Less than 10% of firms report non-zero international assets in Chile, France, Germany, Italy, Netherlands and Thailand. In Japan and the UK, the share of firms reporting any data on international assets is about 70%, and drops to less than 40% if we only use non-zero values.

[9] Foreign sales are defined as sales by foreign affiliates, not the total sales of the firm to foreign markets. These data have been found to be good indicators of exposure in a number of previous studies, including Doidge et al. (2003), He and Ng (1998), Frennberg (1994) and Jorion (1990).

## 4. The extent and robustness of foreign exchange exposure

We begin by running a benchmark specification for exposure where the independent variable is weekly firm- (or industry-) level returns and the right-hand-side variables are the equally-weighted local market return for each country[10] and the change in the exchange rate. One of the first problems that arises when thinking about exchange rate exposure is "Which is the relevant exchange rate?". Many, if not most studies use the trade-weighted exchange rate to measure exposure.[11] As Williamson (2001) notes, the main shortcoming of using a trade-weighted basket of currencies in exposure tests is that the results lack power if a firm is mostly exposed to a small number of currencies. For instance, if a firm is exposed to only one or a few of the currencies within the basket, this may lead to an underestimation of the exposure of the firm. One possible research strategy to mitigate this problem is to create firm- and industry-specific exchange rates. The difficulty with this approach is that it is not clear on what basis these exchange rates should be chosen. As we will show below, firms within the same industry have very different exposure coefficients, suggesting that one needs detailed firm-specific data to isolate which exchange rate is relevant for capturing exchange risk.

Fig. 1a and b show the benchmark results for firm- and industry-level exposure across the eight countries using three different currencies: the trade-weighted exchange rate (in large part to compare our results with those in the literature), the dollar exchange rate, and one additional bilateral exchange rate based on the country's direction of trade data.[12] The bars in the plots show the percentages of firms (Fig. 1a) and industries (Fig. 1b) in the sample with significant (at the 5% level using robust standard errors) exposure using each of the three currencies. The bar labeled "any exchange rate" is the percentage of industries or firms that have significant exposure at the 5% level to at least one of the three listed exchange rates. Note that exposure to "any exchange rate" is an indirect measure of the correlation between the three currencies. If the correlation between the three currencies were zero, exposure to any of the three would simply be the sum of the exposure to the three currencies separately. The scale across Fig. 1a and b is the same to make the comparison between industry- and firm-level exposure easier.

Focusing first on exposure at the firm level, we find that the percent of firms exposed to any of the three exchange rates ranges from a minimum of 14% in Chile to a maximum of 31% in Japan. Looking across countries, in five of the eight countries over 20% of firms exhibit significant exposure, a result that differs markedly from the low levels of exposure found in studies of US firms. Fig. 1b shows the sensitivity of exposure to the three different exchange rates at the industry-level. The extent of exposure is significantly higher

[10] In robustness checks, we compare results using the value-weighted local index and the international index as alternatives to the equally-weighted index. See Fig. 3 below.

[11] Three exceptions are Williamson (2001), Dominguez (1998) and Dominguez and Tesar (2001a). Doidge et al. (2003) use both bilateral rates and trade-weighted exchange rates but "score" total exposure based on one rate.

[12] The country's "major trading partner" is the country with the most trade with the reference country, where trade is defined as the average of exports plus imports in the 1990s. Trade data are taken from the Direction of Trade statistics reported by the International Monetary Fund. If the US is the country's major trading partner, the currency of the second largest trading country is used.

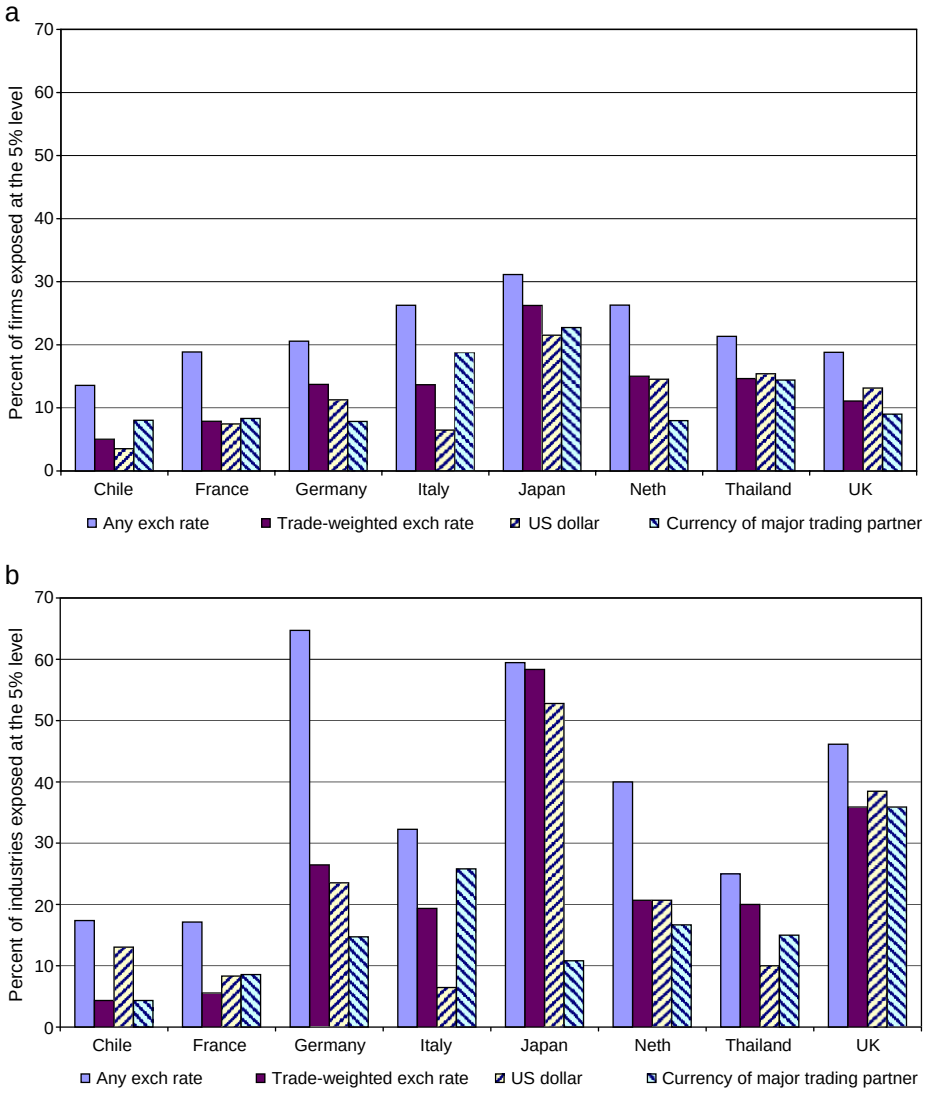


Fig. 1. (a) Firm-level exposure to different exchange rates. Percentages are based on the number of firms in that country with a significant coefficient on the exchange rate in Eq. (1) using robust standard errors and conditioning on the local market index. Exposure to "any exchange rate" indicates the percent of firms for which any of the three exchange rates (trade-weighted, US$ and currency of major trading partner) is significant at the 5% level. (b) Industry-level exposure to different exchange rates. Percentages are based on the number of industries in that country with a significant coefficient on the exchange rate in Eq. (1) using robust standard errors and conditioning on the local market index. Exposure to "any exchange rate" indicates the percent of industries for which any of the three exchange rates (trade-weighted, US$ and currency of major trading partner) is significant at the 5% level.

at the industry level for all the countries, though particularly so for Germany, Japan, the Netherlands and the UK. Over 50% of Japanese industries exhibit significant exposure to the dollar (and the trade-weighted exchange rate). The high level of dollar exposure in Japan is consistent with the fact that most exporting firms in Japan invoice their sales in dollars.[13]

Since much of the literature has focused on exposure to the traded-weighted exchange rate, it is interesting to ask whether exposure to the trade-weighted exchange rate differs from results using a bilateral rate. To get at this question, we calculate the percent of times a firm is exposed to the dollar, but is not exposed to the country's trade-weighted exchange rate. This percentage varies from 15% in Thailand, to 39% in the UK, 65% in France, and 86% in Chile. We take this as an indication that the trade-weighted exchange rate, taken alone, may not be a good indicator of overall exposure for many countries.

It could still be the case that the restriction to the three exchange rates in Fig. 1a and b still misses the exchange rate that is most relevant for a given firm. While we do not have enough information at the firm level to identify the "right" firm-level exchange rate, we can form industry-specific exchange rates based on industry-level trade flows. Although firm-level export and import data is not available for a large sample of firms, information on industry-level international trade is available in Feenstra's (2000) World Trade Flows database. Rather than include the same exchange rate for all firms in a country as we did in Fig. 1a and b, we can now use an exchange rate that reflects industry-level bilateral trade flows. These data will only be a good proxy for firm-level trade flows in industries where trade patterns at the firm level are similar across firms within the same industry. For example, the country that imports the largest fraction of Japanese automobiles is the United States, suggesting that the appropriate currency to include in the exposure regression for Japanese firms in the automotive industry is the US dollar. If, however, some firms in the Japanese automotive industry specialize in sales to the UK and not the United States, the regression coefficient will only pick up exposure to the extent that the dollar–yen rate is correlated with the pound–yen rate.

Fig. 2 presents the percentages of firms that are significantly exposed to these industry-specific trade-based exchange rates.[14] The scale is set to be the same as in Fig. 1a and b for easy comparison. Interestingly the results using both the industry-specific leading export country currencies and the industry-specific leading import country currencies do not differ significantly from the exposure levels we find when we use the dollar rate for all the firms.[15] The fact that the trade-based currency does not identify more exposure could be due to two reasons. The first could be that a firm's engagement in international trade simply doesn't increase a firm's exposure to exchange rate movements—firms either hedge the effects of exchange rate changes, or the exchange rate movements are not the key factor affecting profitability. The second explanation could be that trade does indeed result in exposure to exchange rate movements, but the industry-level exchange rate is

[13] See Dominguez (1998) for further discussion of the link between exposure and invoicing in Japan.

[14] We include results based on just the top export or import country's currency. We also examined exposure to a basket of the top three trade partners' currency and found little difference in the results.

[15] The industry-specific trade data were not available for all the Datastream industries, therefore the exposure estimates in Fig. 2 are based on the subsample of firms in industries for which we have the trade data.

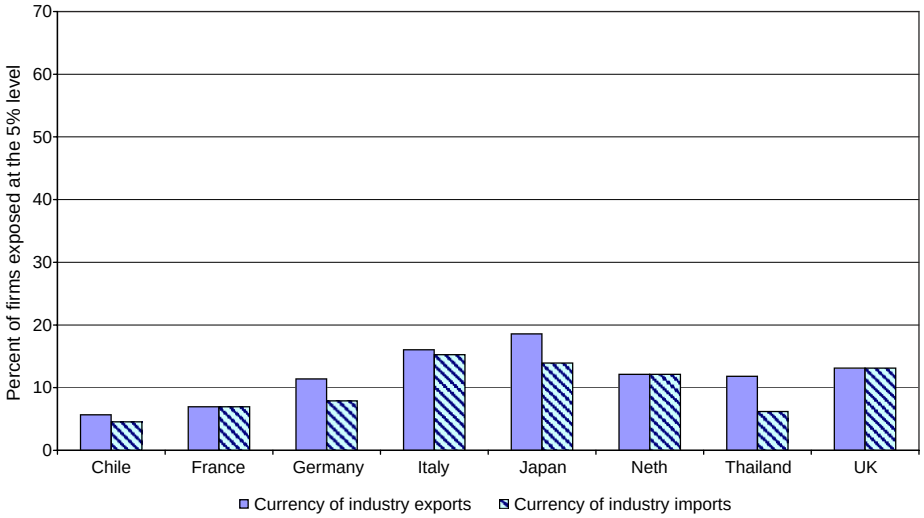


Fig. 2. Firm-level exposure to trade-based industry-specific exchange rates. Percentages are based on the number of firms in that country with a significant coefficient on the exchange rate in Eq. (1) using robust standard errors and conditioning on the local market index. The exchange rates are the currencies of the country's top trading partner by industry. The first bar shows the percent of firms exposed to the currency of its industry's top market for exports. The second bar shows the percent of firms exposed to the currency of its industry's top source of imports. Firms are assigned an industry affiliation according to Datastream. Industry-level trade data are from Feenstra (2000).

misspecified. Although we do not have good data on firm-level trade, we do know that on average, about half of the exposure betas in a given industry are negative and about half are positive, suggesting considerable heterogeneity across firms' exposure even within an industry.[16] Whatever the true explanation, the fact that we do not find that firm-level exposure increases when we use a trade-based currency in the benchmark regression suggests that we are unlikely to find a strong connection between trade and exposure in our second-stage analysis below.[17]

### *4.1. Specification of market index*

Our measure of marginal exposure, which is the one typically used in the literature, reflects the relationship between returns and exchange rates after conditioning on the market. There are two issues that arise when estimating marginal exposure. The first has to do with which market index one should use to proxy for "the market". Empirical tests of the standard CAPM model typically include the return on the value-weighted market

[16] Examples of studies in the literature that test for exposure at the industry level include Allayannis (1997), Allayannis and Ihrig (2000), Bodnar and Gentry (1993), Campa and Goldberg (1995) and Griffin and Stulz (2001).

[17] Forbes (2002) examines the connection between trade linkages and country vulnerability to currency crises for a sample of developing countries. In future work we hope to explore the relationships between the ex ante magnitude of firm level exposures in (currency) crisis and non-crisis countries.

rather than the equally-weighted market. Bodnar and Wong (2003), however, argue that the value-weighted market return is dominated by large firms that are more likely to be involved in international activity and as a consequence are more likely to experience negative cash flow reactions to dollar appreciations than other US firms. Therefore, including the value-weighted return in an exposure test not only removes the "macroeconomic" effects, but also the more negative effect of exchange rates on cash flow in larger firms. This would likely bias tests toward finding no exposure. Alternatively, one could argue that in a world of perfectly integrated capital markets the "market return" might better be proxied by a global portfolio of stocks rather than a national portfolio.

To sort out the impact of the choice of market index on exposure, Fig. 3 shows the percent of firms in each country with a significant exposure to the US dollar under different specifications of the market index. In general the difference in the amount of estimated exposure across the equally-weighted and the value-weighted specification is slight; in some countries (France, Germany and the UK) there is slightly more evidence of exposure when the value-weighted index is used, and in other countries (Italy, Japan and Thailand) there is slightly more exposure with the equally-weighted index. Because the results using the equally-weighted and the value-weighted market indices are so similar, we will use the equally-weighted index in the remaining analysis.

The third bar for each country in Fig. 3 allows for a comparison of the incidence of exposure across the specifications using the local market indices and the international index. The international index is the World index reported by Datastream converted to the reference country's currency. The percentage of firms found to be significantly exposed

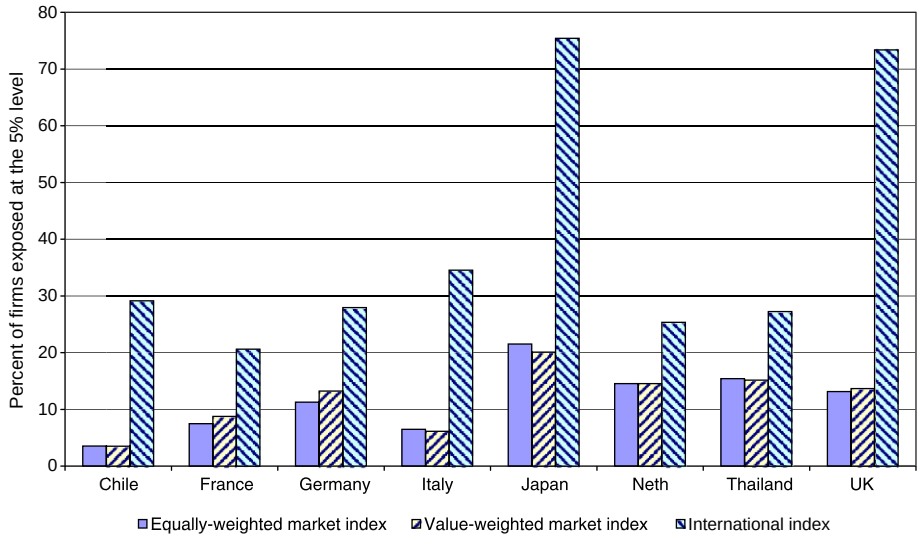


Fig. 3. Sensitivity of firm-level dollar exposure to different market indices. Percentages are based on the number of firms in that country with a significant coefficient (at the 5% level) on the exchange rate in Eq. (1) using robust standard errors and conditioning on one of three market indices. The exchange rate in all regressions is the bilateral rate with the US dollar. All regressions include one of: the equally-weighted local market index, the value-weighted local market index or the international index.

when conditioning on the international index is now substantially higher, with over 20% of firms in all eight countries exposed, and over 70% of firms exposed in Japan and the UK. The likely reason for the increase in the significance of the exchange rate in the benchmark regression is due to the fact that the international index does a poor job of explaining returns. The average adjusted-$R^2$ in the regression using the international index falls relative to the adjusted-$R^2$ when the local market index is used, in some cases by 50% or more.[18] Thus, more firms appear to be exposed simply because the exchange rate is picking up more of the variability of returns and the market is picking up substantially less. It is also the case that correlations between the international index and changes in the relevant exchange rate are generally high (ranging from 0.22 to 0.48) suggesting that multicollinearity may be a problem.[19] In the remaining tests, we will use the local rather than the international index as our conditioning variable, though it is worth noting that this may downward bias our estimates of exposure.[20]

Another potential problem with conditioning on the market is that, in cases where the market index as a whole is correlated with the exchange rate, marginal firm-level exposure will appear to be small even though aggregate market-level exposure is high. Conceivably some of the relatively lower levels of exposure, for example in our two developing countries, found in Figs. 1a,b and 2 could be explained by high correlations between the market index and exchange rates. We did not find convincing evidence that this is the case. In general, correlations between market indices and exchange rates are small and vary considerably across countries and over time. For example, over the full sample of data (1980–1999) the weekly correlation between the equally-weighted market index and the bilateral exchange rate with the dollar ranges from small and negative (Thailand, −0.15; Japan, −0.07; Chile, −0.001) to small and positive (Germany, 0.12; Netherlands, 0.25).[21] As a consequence, the reported levels of exposure are unlikely to be biased downward because the market index is absorbing the impact of movements in the exchange rate.

### 4.2. Sensitivity of exposure to horizon

Several studies of exposure have found that the extent of estimated exposure is increasing in the return horizon (see, for example, Bartov and Bodnar, 1994; Allayannis, 1997; Bodnar and Wong, 2003; Chow et al., 1997a,b). Indeed, most studies of exposure are conducted using monthly returns, suggesting that our results based on weekly returns

[18] As in most CAPM regressions, the $R^2$'s are small under any specification. The key point here is that the explanatory power of the regression is much smaller when the international index is used. We do not report the $R^2$'s here but they are available upon request.

[19] An international index, by its very nature, will be correlated with exchange rates given that it contains returns for various countries which then all need to be translated into one currency.

[20] Connolly et al. (2000) indirectly measure exposure by testing whether the relevant regional or country indices outperform the international index in explaining cross-country firm-level returns.

[21] For completeness, we examined the correlation between the market index (equally-weighted and value-weighted) and the exchange rate (trade-weighted, US dollar, and currency of major trading partner) over the full time period and over various subperiods. Although there were some instances when the correlation was significantly different from zero, no consistent relationship between a particular exchange rate and the market index emerged that would lead to a serious underestimation of exposure based on Eq. (1).

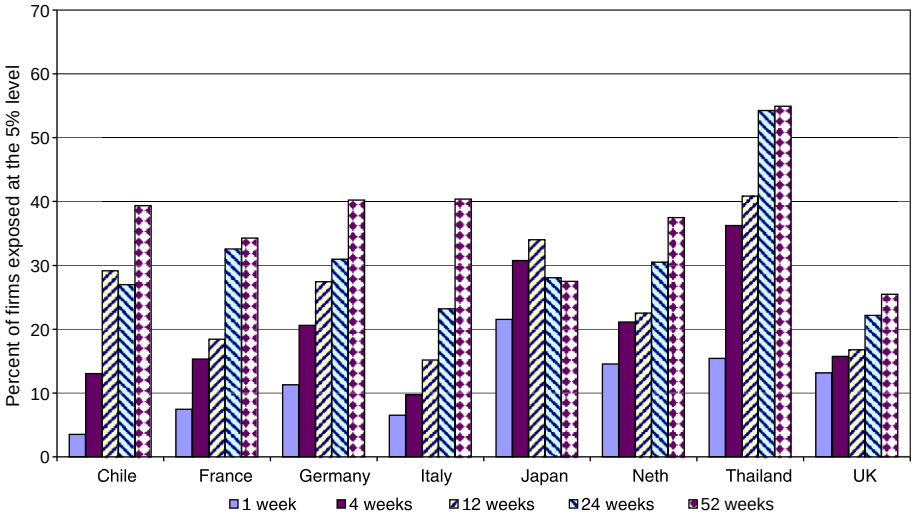


Fig. 4. Sensitivity of firm-level dollar exposure to the return horizon. Percentages are based on the number of firms in that country with a significant coefficient (at the 5% level) on the exchange rate in Eq. (1) using robust standard errors and conditioning on the equally-weighted local market index. The exchange rate is US dollar exchange rate. Returns are based on rolling regressions using 1-week, 4-week, 12-week, 24-week and 52-week lengths estimated with GMM, correcting for serial correlation.

may understate the true extent of exposure. Fig. 4 shows the percent of firms with significant US dollar exposure in our eight-country sample at the 1-, 4-, 12-, 24- and 52-week return horizons. The results are based on rolling regressions estimated by GMM, correcting for serial correlation. Consistent with the literature, we find that exposure is indeed increasing in the return horizon for most firms in our sample. Exposure in Chile stands out as the most extreme case. Using weekly returns, less than 4% of Chilean firms appeared to be exposed to the US dollar. That fraction increased to 30% at the quarterly horizon and to 39% at the yearly horizon. Japan is the only country in the sample where exposure peaks at the quarterly horizon.[22]

The fact that exposure increases with the return horizon raises the possibility that the second-stage regressions might be more successful in explaining exposure if one were to use exposure coefficients based on monthly or quarterly data. Repeating the second-stage regressions for Chile and Italy (the two countries with the largest increase in exposure level with an increase in horizon) and the UK and Japan (the countries with the most significant exposure over all horizons), with monthly and quarterly exposure coefficients, however, did not change the qualitative conclusions we report below. Analysis of the beta estimates for firms in these countries indicates that there is quite a bit of variation in both the magnitude and sign of betas across the three return horizons. However, there is little beta variation for those firms with significant exposure betas across all three horizons—

[22] Analysis of the beta coefficients at different horizons suggests that the magnitude, statistical significance, and in many cases the sign of a firm's exposure coefficient changes across different horizons.

suggesting that it is these firms in the second stage cross-section that are driving the results. Thus, we will continue to use exposure estimates based on weekly returns in the second-stage analysis below.

### 4.3. Magnitude and direction of exposure

Table 2 provides summary information on the sign and the magnitude of the exposure coefficients. Part A of Table 2 reports the percent of exposure coefficients that are positive and the percent that are negative. Currencies are measured in units of the reference country's currency per foreign currency (TW, $US or major trading partner). In regressions that include changes in the trade-weighted exchange rate three of the countries (Chile, Germany and Italy) have about evenly split positive and negative exposure. In another four countries (France, Japan, the Netherlands and the UK) 60–70% of firms exhibit positive exposure (meaning that a depreciation of the home currency results in an increase in firm share value). In Thailand, 79% of exposed firms have negative exposure coefficients,

Table 2
Direction and magnitude of FX exposure

| | Chile | France | Germany | Italy | Japan | Neth | Thailand | UK |
|---|---|---|---|---|---|---|---|---|
| *A. Direction of exposure* | | | | | | | | |
| 1. TW exchange rate | | | | | | | | |
| % positive | 50 | 61 | 54 | 53 | 62 | 63 | 21 | 70 |
| 2. $US | | | | | | | | |
| % positive | 43 | 53 | 43 | 54 | 47 | 42 | 25 | 45 |
| *B. Average increase in $R^2$ (in percent)* | | | | | | | | |
| 1. Across all firms | | | | | | | | |
| tw exchange rate | −0.017 | 0.015 | −0.028 | 0.150 | 0.250 | 0.141 | 0.632 | 0.077 |
| US$ | 0.015 | −0.001 | −0.004 | 0.031 | 0.233 | 0.178 | 0.707 | 0.083 |
| Major trading partner | 1.469 | 0.023 | −0.004 | 0.218 | 0.507 | 0.143 | 0.380 | 0.041 |
| 2. At 5% level of significance | | | | | | | | |
| tw exchange rate | 0.851 | 1.060 | 0.418 | 1.099 | 0.924 | 1.187 | 2.641 | 1.119 |
| US$ | 2.512 | 1.171 | 0.480 | 0.975 | 1.111 | 1.271 | 2.837 | 1.147 |
| Major trading partner | 1.469 | 1.234 | 0.471 | 1.017 | 1.207 | 1.363 | 2.243 | 1.159 |
| *C. Average magnitude of exposure* | | | | | | | | |
| 1. Significant positive exposure | | | | | | | | |
| tw exchange rate | 0.421 | 2.027 | 0.637 | 0.728 | 0.334 | 1.452 | 0.812 | 0.385 |
| US$ | 0.568 | 0.364 | 0.168 | 0.426 | 0.421 | 0.650 | 0.739 | 0.457 |
| Major trading partner | 0.253 | 9.061 | 0.717 | 0.563 | 0.187 | 3.327 | 0.602 | 0.435 |
| 2. Significant negative exposure | | | | | | | | |
| tw exchange rate | −0.117 | −1.123 | −0.502 | −0.548 | −0.417 | −1.801 | −1.009 | −0.465 |
| US$ | −0.777 | −0.555 | −0.180 | −0.268 | −0.361 | −0.270 | −1.024 | −0.356 |
| Major trading partner | −0.467 | −1.509 | −0.244 | −1.103 | −0.248 | −21.364 | −0.668 | −0.399 |

Part A of the table reports the percent of firms in each country with positive exposure. Part B reports the average increase in $R^2$ from adding the change in the exchange rate to the market model. Part C reports the average magnitude of the coefficient on the change in the exchange rate. Results are based on the benchmark specification using the equally-weighted market index and one of the three exchange rates (trade-weighted, $US, or currency of major trading partner). All significance levels are set at 5% based on robust standard errors.

suggesting that a depreciation of the baht generally led to a decrease in the value of Thai firm share values.[23]

We also provide information on the average increase in the adjusted $R^2$ (a measure of goodness of fit) at the firm level when we include the exchange rate as an explanator of excess returns (Part B of Table 2). The first set of results (B.1) includes all firms, and the second set of results (B.2) includes only those firms with significant (at the 5% level) exposure. When averaging across all firms and exchange rates, the increase in the adjusted $R^2$ is small, ranging from $-.004\%$ to 1.5%. Note that the $R^2$'s are very small to begin with (i.e. the explanatory power of the market index for returns is low) and the addition of the exchange rate adds little additional explanatory power. When we average across the regressions in which exchange rate exposure is found to be statistically significant the increase in the adjusted $R^2$ ranges from about one-half of 1% to nearly 3%. It is interesting to note that although our two developing countries, Chile and Thailand, show relatively low levels of industry and firm exposure, the average increase in adjusted $R^2$ when we include an exchange rate in the CAPM specification for these countries is relatively high. This suggests that although fewer firms in these countries are exposed, those that are exposed have a relatively high degree of exposure. This phenomenon also shows up in the average size of the coefficient on the exposure variable provided in Part C of the table.

Thus far, we have focused on the extent of exposure as reflected in the fraction of firms that have significant exposure coefficients, but we are also interested in the magnitude of the exposure to exchange rate risk. In other words, it may be that a significant fraction of firms is exposed to exchange rate risk, but we would also like to know if that exposure is economically significant. Part C of Table 2 shows the average magnitude of the significant exposure coefficients, sorted by sign. The figures suggest that the magnitude of the positive US dollar exposure beta ranges from 0.2 to 0.7. A positive coefficient of 0.2 indicates that a 1% appreciation of the US dollar relative to the local currency is correlated with a 0.2% increase in local stock returns. France and the Netherlands exhibit the largest betas with respect to changes in the exchange rate of their major trading partners. The negative betas are of roughly the same order of magnitude. Averaging across significant dollar exposure betas across countries, the data suggest that a 1% change in the exchange rate is correlated with a one-half percent change in stock returns.

### 4.4. Robustness across sub-samples

The exposure results we have reported up to this point are based on regressions over the period January 1980–May 1999. To test for the sensitivity of our exposure estimates to the sample period, we divide the sample in two different ways. First, we examine the extent of exposure using just the last five years of data in our sample. This will be particularly useful for our second-stage analysis as coverage of many of our explanatory variables, such as foreign sales and international assets, increase dramatically in the second half of the 1990s.

[23] It is likely that the main reason that a depreciation of the baht led to a fall in the value of Thai firms is that those firms had large dollar-denominated liabilities. See also Allayannis et al. (2003) for evidence on large net foreign liabilities for East Asian firms.

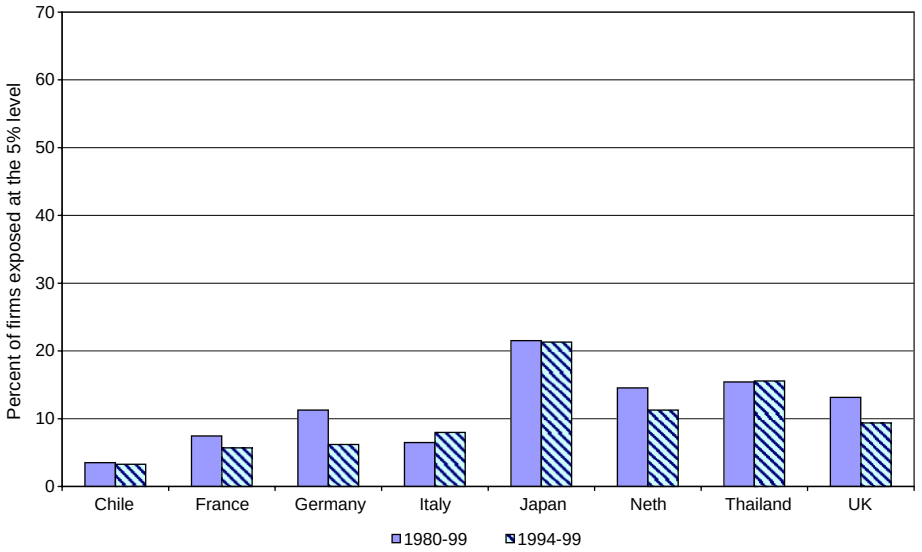


Fig. 5. Firm-level dollar exposure in the full sample (1980–1999) and the last 5 years (1994–1999) of data. Percentages are based on the number of firms in that country with a significant coefficient on the exchange rate in Eq. (1) using robust standard errors and conditioning on the equally-weighted local market index. Significance is at the 5% level.

Second, we divide our data into three separate sub-periods and examine the consistency of the beta coefficients across subsamples.

Turning first to the results based on the 1994–1999 period, Fig. 5 provides a comparison of the extent of firm-level US dollar exposure in the full sample and in the last 5 years of the sample. The figure shows that there is very little, if any, difference in the overall extent of exposure across the samples.

Next we look at the consistency of our beta coefficients across three subperiods. Rather than arbitrarily splitting the full sample into three equally sized subperiods, we selected subperiods on the basis of changes in the underlying currencies used for each country.[24] For example, in Thailand all the exchange rate "action" occurs during and after the currency crisis of 1997. Arbitrarily splitting the Thai sample at an earlier point would not allow us to focus on the period in which we might expect firm and industry level exposures to change. Also, by splitting the sample in this way we are able to test whether exposure levels (or changes in exposure) are highest during periods of home currency appreciation and/or depreciation, and whether changes in the underlying volatility of the home currency are related to exposure.[25]

[24] We also perform the subsample robustness tests over equal sized subperiods for the sake of completeness—results over these subsamples are qualitatively similar to those reported in Table 3.

[25] The subperiods used for each of the countries are as follows: Chile (10/4/88–5/12/92, 5/19/92–4/18/95, 4/25/95–5/18/99); France (1/1/80–6/3/86, 6/10/86–5/23/95, 5/30/95–5/18/99); Germany (1/1/80–3/5/85, 3/12/85–2/17/87, 2/24/87–5/18/99); Italy (1/1/80–9/8/92, 9/15/92–4/25/95, 5/2/95–5/18/99); Japan (1/1/80–2/19/85, 2/26/85–4/18/95, 4/25/95–5/18/99); Netherlands (1/1/80–3/5/85, 3/12/85–1/5/88, 1/12/88–5/18/99); Thailand (1/1/80–6/17/97, 6/24/97–1/13/98,1/20/98–5/18/99); UK (1/1/80–3/5/85, 3/12/85–12/1/92, 12/8/92–5/18/99).

Table 3
Stability of firm-level dollar exposure across subsamples

| | Chile | France | Germany | Italy | Japan | Neth | Thailand | UK |
|---|---|---|---|---|---|---|---|---|
| *A. Percent of firms exposed* | | | | | | | | |
| in full sample | 3.5 | 7.5 | 11.3 | 6.5 | 21.5 | 14.6 | 15.4 | 13.1 |
| in first sub-sample | 7.4 | 2.6 | 1.6 | 6.6 | 9.8 | 13.0 | 11.4 | 7.3 |
| in second sub-sample | 7.4 | 11.1 | 4.8 | 6.2 | 17.8 | 9.8 | 16.7 | 17.4 |
| in third sub-sample | 4.8 | 5.3 | 9.0 | 9.7 | 24.2 | 14.6 | 15.5 | 9.6 |
| *B. Percent of firms exposed* | | | | | | | | |
| Across two or more subsamples | 0.6 | 0.0 | 0.0 | 2.6 | 10.4 | 7.5 | 3.7 | 3.4 |
| in all 3 subsamples | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 1.0 | 0.0 | 1.7 |
| in the full sample only | 0.5 | 1.8 | 9.3 | 1.8 | 3.3 | 2.3 | 6.2 | 1.8 |
| *C. Percent of firms whose sign on the beta coefficient* | | | | | | | | |
| Changes from subperiod 1 to 2 | 53.0 | 56.4 | 51.7 | 43.6 | 49.2 | 45.0 | 54.9 | 54.8 |
| Changes from subperiod 2 to 3 | 52.3 | 45.1 | 61.9 | 50.7 | 35.4 | 45.9 | 53.7 | 44.9 |
| does not change acrss subperiods | 22.7 | 28.2 | 20.0 | 28.4 | 35.4 | 33.0 | 21.2 | 26.3 |

The table reports the percent of firms in each country that has a significant exposure coefficient in each of the three sub-samples. Results are based on the benchmark specification using the equally-weighted market index and the dollar exchange rate. All significance levels are set at 5% based on robust standard error. The subsamples are described in the text.

Table 3 reports the percent of firms exposed to the US dollar in the full sample and each of the three subsamples. In general, the extent of exposure is about the same in the full and in the three subsamples.[26] This suggests that our finding of exposure at the aggregate level is not driven by a particular subsample and that even though countries experienced different amounts of exchange rate volatility in different time periods, the extent of exposure is fairly constant. As an additional robustness check, we divided the exchange rate variable according to whether the change in the exchange rate was large (where "large" is defined as the top quartile of exchange rate changes) or small for two of the countries in our sample, Germany and UK.[27] We find that for the full sample period the extent of exposure in the large exchange rate change regime is slightly higher, though over the last 5-year subsample the extent of exposure is the same over both currency regimes.

While the aggregate amount of exposure remains roughly constant, we are also interested in whether the same set of firms is exposed across subsamples and in the stability of the direction of exposure. Part A of Table 3 reports the subsample exposure results for the USD bilateral rate. Part B shows the percent of firms exposed in one sample that are still exposed in another subsample or the full sample. The table shows that few firms are exposed across all three subsamples, and only a small fraction of firms are exposed across two subsamples.[28] This suggests that while there may be a fairly constant level of exposure in the economy as a whole, which firms are exposed varies over time. Part C of Table 3 reports the stability of the exposure coefficients themselves over time.

[26] This holds for all three currencies. These results are available upon request.
[27] Doidge et al. (2003) and Priestley and Odegaard (2003) find evidence that exposure is related to the size and direction of exchange rate changes.
[28] Percentages are based on the sample of firms that exist across the relevant sub-periods.

In 20–35% of the firms that exist over all the subperiods, the sign on the exposure coefficient stays the same across the three subsamples. And, in about half of the sample of firms that exist in at least two subperiods, the exposure coefficient switches sign across at least one subsample, suggesting that both the incidence of exposure (i.e. who is exposed) and the direction of exposure is time-varying.

The most likely explanation for the time-variation in exposure across the sample is that it reflects the adaptability of firms to exchange rate risk. Firms that find themselves highly exposed in one period will react by changing operational or financial policies to offset (or exploit) any adverse (positive) consequences of the exposure.[29] Unfortunately, the detailed firm-specific time series data necessary to confirm this conjecture is not available for the wide cross-section of firms included in this study. However, there do exist firm- and industry-level data that may help us distinguish which firms are most likely to find themselves exposed to foreign exchange risk. In the next section of the paper we attempt to explain the average level of firm exposure to exchange rate movements using these data.

## 5. Explaining exposure: second-stage regressions

In this section we attempt to link the foreign exchange exposure estimates we have documented in the previous section to firm- and industry-specific characteristics. We test a series of hypotheses by running a second-stage regression that takes the estimated exposure betas from Eq. (1) and regresses these on a variety of potential explanatory variables.

$$\beta_{2,i} = \lambda_0 + \gamma_1 X_i + \varepsilon_i. \tag{2}$$

The basic regression specification has the firm-level weekly dollar exposure beta estimated over the 1994–1999 period as the dependent variable and firm- and industry-level information as explanatory variables.

**Hypothesis 1.** Firm-level dollar exposure and firm characteristics.

Our first testable hypothesis is that dollar exposure is a function of firm characteristics, namely a firm's size and its industry affiliation. Our prior about the relationship between firm size and exposure is ambiguous. On the one hand, large firms may be more likely to be engaged in international activities, and therefore more likely to be affected by exchange rate movements. On the other hand, larger firms may be more likely to hedge exchange rate risk, so that smaller firms may be more likely to be exposed.[30] To capture firm size, we sort each country's sample of firms into thirds based on firm-level market capitalization. Separate dummies are used for large-sized (top-third) and medium-sized (middle-third) firms (small-sized firms being the excluded category). We also examine whether a firm's industry affiliation is linked to exposure. Datastream provides a set of (2-

[29] Allayannis and Ihrig (2001) also find in their study of US industries that exchange rate exposure varies both over time and switches sign. They hypothesize that these changes in industry exposure are linked to changes in imported input share, export share and the value of markup.

[30] Nance et al. (1993) suggest that larger firms are more likely to hedge exchange rate risks.

digit) industry groupings (10 categories, see the Appendix for a detailed breakdown), from which we create a set of dummy variables (the excluded category being industry 50 "retailers, restaurants, transport").[31]

The results from the second-stage regressions for each of the eight countries in our sample are reported in part A of Table 4. The black cells indicate a significant negative coefficient at the 5% level (based on robust standard errors) and the grey cells indicate a significant positive coefficient at the 5% level (based on robust standard errors). The first thing to note from the table is that firm size is generally not systematically related to exposure betas. It is also striking that most of the significant industry coefficients are found for Japan.[32] Looking over all eight countries, the results suggest that neither firm size nor industry affiliation consistently explain the variation in firm level exposure.[33]

The specification of Eq. (2) is somewhat restricted, however, in that it asks not only whether firm size and industry play a role in foreign exchange exposure, but it also implicitly restricts the direction of the exposure to be the same within each of those categories. It is possible, for example, that two firms in the same industry are strongly affected by exchange rate movements, but one firm benefits from an exchange rate appreciation while another firm is made worse off by an appreciation. To test whether our firm-level explanatory variables contain information about the magnitude of exposure, if not the direction of the exposure, we next regress the square-root of the absolute value of the exposure betas on the same set of firm and industry characteristics.[34] The results are reported in Part B of Table 4. The number of significant coefficients on the firm size dummy variables rises substantially when we ignore the sign on the exposure betas. Now firm size is statistically significant for six of the eight countries and the sign on the coefficients suggests that large- and medium-sized firms are likely to have lower levels of exposure than the excluded category, small firms.[35] It is also now the case that the

[31] We also tried using a more disaggregated set of industry groupings (at the 4-digit level) in our basic second stage regression specification. These results, reported in Dominguez and Tesar (2001b), are qualitatively the same as those reported here using 2-digit industry categories.

[32] Chamberlain et al. (1997) find that while the returns on US banks are sensitive to exchange rate changes, Japanese bank returns are not exposed. In Table 4 we find evidence that firms in the Japanese finance industry (which includes banking, insurance and real estate) are likely to have higher levels of exposure than are firms in our excluded category (Distributors, Retail, Hotel, Rest and Transport).

[33] We also experimented with interaction effects between firm size and industry affiliation but found little evidence that such interactions are operative in the data.

[34] A number of studies in the literature estimate the second-stage regression using the simple absolute value of the exposure beta as the dependent variable. This imposes a truncated bias. We include the square root of the absolute value of the exposure beta, which allows for both positive and negative values and therefore (largely) leaves the error term normally distributed. It is still the case, however, that this specification restricts the error term from taking on extremely large negative values. An alternative transformation of the betas, used in Dominguez and Tesar (2001b), which takes the log odds of the absolute value of beta, is undefined for values of beta that exceed (−1,1). Our results are qualitatively similar using the two possible transformations of the exposure betas.

[35] It is worth noting that if derivatives are used by larger firms to hedge exposures, we should expect a negative relationship between large firms (derivative use) and positive exposure and a positive relationship between large firms and negative exposures. It is unfortunately not possible to test this hypothesis directly due to the problem of truncation bias (described in footnote 34).

significant industry coefficients are more evenly distributed across the eight countries. However, it remains true that the signs on the industry dummies are generally not consistent across countries. For example, in Germany, Italy and the Netherlands firms in the Mining, Oil and Gas industry are less exposed than other firms, while the reverse is true in Japan and the UK. The one industry in which firms across all the countries seem to be exposed in the same way is the electric, gas and water industry, where the results suggest that firms in this industry are less exposed than other firms.

**Hypothesis 2.** Firm-level dollar exposure and international activity.

The second hypothesis we test is whether a firm's activities in international markets increase the likelihood of exchange rate exposure.[36] We conjecture that the profitability of multinational firms, and/or firms with significant foreign sales or international assets, will increase with a depreciation of their home currency relative to the dollar, yielding a positive coefficient in the first-stage regressions. Those betas, then, will be positively linked with multinational status. As measures of international activity we include (i) a dummy variable denoting whether the firm is a multinational corporation, (ii) the firm's percentage of foreign to total sales, and (iii) the firm's percentage of international to total assets. As described earlier in the paper, firm level data on foreign sales and foreign assets is limited for most countries, so that the degrees of freedom in these regression specifications are often quite low. Further, we would expect that firms that are designated as multinational are also likely to have high levels of foreign assets and foreign sales, so that the explanatory power of the three variables included in this table should be qualitatively similar.[37]

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Notes to Table 4:
The table reports the significance of the coefficient on the dummy variable for firm size or industry affiliation in the following regression

$$\beta_{2i} = \lambda_0 + \gamma_1 X_i + \varepsilon_i$$

In part A the dependent variable is the weekly dollar exposure coefficients estimated using Eq. (1) for the 1994–1999 period.
In part B the regression is repeated using exposure coefficients that are transformed by taking the absolute value of the square root of the exposure betas.
denotes a significantly positive coefficient at the 5% level based on robust standard errors.
denotes a significantly negative coefficient at the 5% level based on robust standard errors.
denotes a statistically insignificant coefficient at the 5% level based on robust standard errors.
(1) Reference industry for creating firm-size dummies is small, defined as the bottom one-third of the distribution of the market capitalizations.
(2) Reference industry for creating industry dummies is Distrib, Retail, Hotel, Rest, Transport.
(3) Transformed beta is the square root of the absolute value of the exposure beta.

[36] A number of studies in the literature (for example, Jorion, 1990; Bartov et al., 1996; Gao, 1996; Bodnar and Weintrop, 1997; He and Ng, 1998) test for exchange rate exposure in samples of exclusively multinational firms.
[37] Note that the multinational status variable is a (1,0) dummy variable while the foreign sales and assets variables are in percentages. We also tried specifications of Eq. (2) that include dummy variables which distinguish large, medium and small percentages of foreign sales or assets. We find that results generally did not change depending on how we specify the variables (as dummies or percentages).

Table 4
Firm-level US dollar exposure and firm characteristics

| | | Chile | France | Germany | Italy | Japan | Neth | Thailand | UK |
|---|---|---|---|---|---|---|---|---|---|
| Part A. Dependent variable: exposure beta estimated over 1994–1999 | | | | | | | | | |
| Firm size (1) | Large | | | | | | | | |
| | Medium | | | | | | | | |
| Industry (2) | Mining, Oil and Gas | | | | | | | | |
| | Chem, Const, Forestry, Steel | | | | | | | | |
| | Aerosp, Indust, Elect, Eng | | | | | | | | |
| | Auto, Hhold goods, Textiles | | | | | | | | |
| | Bev, Food, health, Pkg, Pharm, Tob | | | | | | | | |
| | Food and drug retail, Telecom | | | | | | | | |
| | Elect, Gas and Water | | | | | | | | |
| | Finance, Ins and Real estate | | | | | | | | |
| | Info technol., Software and comp | | | | | | | | |
| Part B. Dependent variable: transformed exposure beta estimated over 1994–1999 (3) | | | | | | | | | |
| Firm size (1) | Large | | | | | | | | |
| | Medium | | | | | | | | |
| Industry (2) | Mining, Oil and Gas | | | | | | | | |
| | Chem, Const, Forestry, Steel | | | | | | | | |
| | Aerosp, Indust, Elect, Eng | | | | | | | | |
| | Auto, Hhold goods, Textiles | | | | | | | | |
| | Bev, Food, health, Pkg, Pharm, Tob | | | | | | | | |
| | Food and drug retail, Telecom | | | | | | | | |
| | Elect, Gas and Water | | | | | | | | |
| | Finance, Ins and Real estate | | | | | | | | |
| | Info technol., Software and comp | | | | | | | | |
| Degree of Freedom | | 194 | 220 | 201 | 274 | 485 | 210 | 386 | 382 |

The results of these tests are reported in Table 5, where again a black cell indicates a significant negative coefficient and a grey cell a significant positive coefficient. The results suggest that there does appear to be a significant relationship between exposure and international activity, especially for Germany, Japan and the UK. The results also suggest that the sign of exposure matters: the second-stage coefficients in the top of the table are all positive, and there is less explanatory power when we use the transformed beta coefficients. This is consistent with our conjecture that multinationals, more than other firms in the sample, are likely to benefit from a currency depreciation.

Table 5
Firm-level US dollar exposure and international activities

Part A. Dependent variable: exposure beta estimated over 1994–1999

| | Chile | France | Germany | Italy | Japan | Neth | Thailand | UK |
|---|---|---|---|---|---|---|---|---|
| Multinational status(1) | | | | | | | | |
| Foreign sales(2) | | | | | | | | |
| International assets(3) | | | | | | | | |

Part B. Dependent variable: transformed exposure beta estimated over 1994-1999 (4)

| | Chile | France | Germany | Italy | Japan | Neth | Thailand | UK |
|---|---|---|---|---|---|---|---|---|
| Multinational status(1) | | | | | | | | |
| Foreign sales(2) | | | | | | | | |
| International assets(3) | | | | | | | | |

The table reports the significance of the coefficient on the dummy variable for each firm's multinational status, its foreign sales and its international assets in the following regression:

$$\beta_{2i} = \lambda_0 + \gamma_1 X_i + \varepsilon_i$$

In part A the dependent variable is the weekly dollar exposure coefficients estimated using Eq. (1) for the 1994–1999 period.

In part B the regression is repeated using exposure coefficients that are transformed by taking the absolute value of the square root of the exposure betas.

denotes a significantly positive coefficient at the 5% level based on robust standard errors.

denotes a significantly negative coefficient at the 5% level based on robust standard errors.

denotes a statistically insignificant coefficient at the 5% level based on robust standard errors.

indicates missing value due to insufficient data.

(1) The degrees of freedom are 221, 202, 275, 486, 211, 383, respectively, for the 6 countries (excluding Chile and Thailand).

(2) The degrees of freedom are 25, 118, 106, 193, 365, 125, 211, 292, respectively, for the eight countries.

(3) The degrees of freedom are 48, 58, 70, 337, 36, 203, 272, respectively, for the seven countries (excluding Chile).

(4) Transformed beta is the square root of the absolute value of the exposure beta.

**Hypothesis 3.** Firm-level dollar exposure and international trade.

Another plausible hypothesis regarding exchange rate exposure suggests that firms that are heavily involved in international trade will be more exposed than purely domestic firms. Table 6 presents the results of four variants of our second stage regression (2) that include various proxies for firm-level international trade. The first specification includes a dummy variable that indicates whether the firm is in a traded-goods industry or a non-traded industry (see Appendix Table A1 for the list of industries included in each category). There is no evidence that being a "traded" or a "nontraded" classified firm is systematically linked to exposure.

Our second "trade" specification includes the volume of world trade flows in exports and imports for each country by industry.[38] Note that the hypothesis is that an exporter will be more likely to benefit from a depreciation (hence a positive coefficient in the second stage) and an importer will be more likely to be harmed by a depreciation (yielding a negative coefficient). The results are strongest for importing firms, where we find a negative relationship between exposure and the industry-level volume of imports for Germany, Italy and Japan.

Campa and Goldberg (1997) provide another measure of industry-specific trade orientation for two of our eight countries, Japan and the UK. They provide measures of export share, import share and imported input shares for a number of manufacturing industries in 1993. These data provide another proxy for relative levels of trade across industries. The results for regression (2) using these data, presented in Table 6, suggest that all three measures of trade shares are statistically significant for Japan. In the case of Japan, higher export shares are indeed positively related to firm-level dollar exposure betas in that industry, while higher imports and imported input shares in an industry are negatively related to firm level exposure in that industry. While these results are more encouraging for the hypothesis that trade is related to exposure, it is difficult to know whether the results for Japan would also hold in a broader set of countries, especially given that the results are insignificant for the UK.

The final hypothesis we examine is whether market concentration is related to exposure. The conjecture is that firms in less competitive industries are more likely to pass exchange rate movements through to prices, and therefore profitability will not be affected by exchange rate changes. We would expect, then that the coefficient on indicators of competitiveness would be negative in our second stage regressions. We use two measures to proxy for market concentration—a Herfindahl index and a markup index, both based on OECD data. We find that this hypothesis only seems to hold for Japan using the mark-up index. For France and the UK, the Herfindahl index is significant, but positive. One explanation for this result is that industries with high Herfindahl indices may contain a few large firms and numerous smaller firms, so that we may be picking up the small firm size effect again with this indicator.

[38] Again, because the trade data are not available for all the Datastream industries, these regressions include the subsample of firms in the industries covered by the World Trade Flows data. In addition, we include both the world trade flows as well as the bilateral flows to the US (to correspond with the dollar exposure betas). Results using the US bilateral flows are qualitatively similar to those using world trade flows.

### 5.1. Pooled regressions explaining exposure

All of the analysis we have conducted thus far has been on a country-by-country basis. It may be the case, however, that there is not enough variation within countries to identify the distinguishing characteristics of exposed firms relative to non-exposed firms. As a final robustness check, Table 7 shows the results of a pooled cross-country regression of the firm-level dollar exposure betas on the indicators for a firm's international activity and market structure. We also include country fixed effects. Interestingly, we find that our three indicators of international activity, and industry-level exports and imports again emerge with significant coefficients. We also find that the Herfindahl index enters significantly and with a positive sign. This confirms the results we find in the country-by-country regressions.

## 6. Conclusions

We use firm- and industry-level stock returns to test for the presence of exchange rate exposure in eight countries. We find a significant amount of exposure to a range of different exchange rates. We find that at the country level, the extent of exposure is robust, although which firms are affected by movements in the exchange rate and the direction of exposure depends on the specific exchange rate and varies over time. We postulate that exchange rate exposure may be linked to a number of firm- and industry-level characteristics. Our second-stage regressions confirm that exposure is more prevalent in small- (rather than large- or medium-) sized firms and in firms engaged in international activities (measured by multinational status, holdings of international assets and foreign sales). We also find weak evidence linking industry-level measures of international trade and competitiveness to firm-level exposure.

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Notes to Table 6:
The table reports the significance of the coefficient on the dummy variable for the firm's industry measure of world trade flow, trade shares, Herfindahl index and markup index in the following regression:

$$\beta_{2i} = \lambda_0 + \gamma_1 X_i + \varepsilon_i$$

In part A the dependent variable is the weekly dollar exposure coefficients estimated using Eq. (1) for the 1994–1999 period.
In part B the regression is repeated using exposure coefficients that are transformed by taking the absolute value of the square root of the exposure betas.
denotes a significantly positive coefficient at the 5% level based on robust standard errors.
denotes a significantly negative coefficient at the 5% level based on robust standard errors.
denotes a statistically insignificant coefficient at the 5% level based on robust standard errors.
indicates missing value due to insufficient data.
(1) Industry dummy set to 1 if firm is in a traded-good industry. Dof are 192, 214, 202, 263, 483, 210, 347 and 382, respectively, for the 8 countries.
(2) Feenstra world trade industry-level volume data. Degrees of freedom are 86, 110, 111, 130, 279, 97, 176, 123, respectively, for the 8 countries.
(3) Campa Goldberg trade share data. Degrees of freedom are 253 for Japan and 105 for the UK.
(4) Herfindahl index dofs are 105, 108, 295, 130 for France, Germany, Japan, UK. Markup index dof are 89, 83, 93, 225, 41, 94 (excl Chile and Thailand).
(5) Transformed beta is the square root of the absolute value of the exposure beta.

Table 6
Firm-level US dollar exposure and international trade

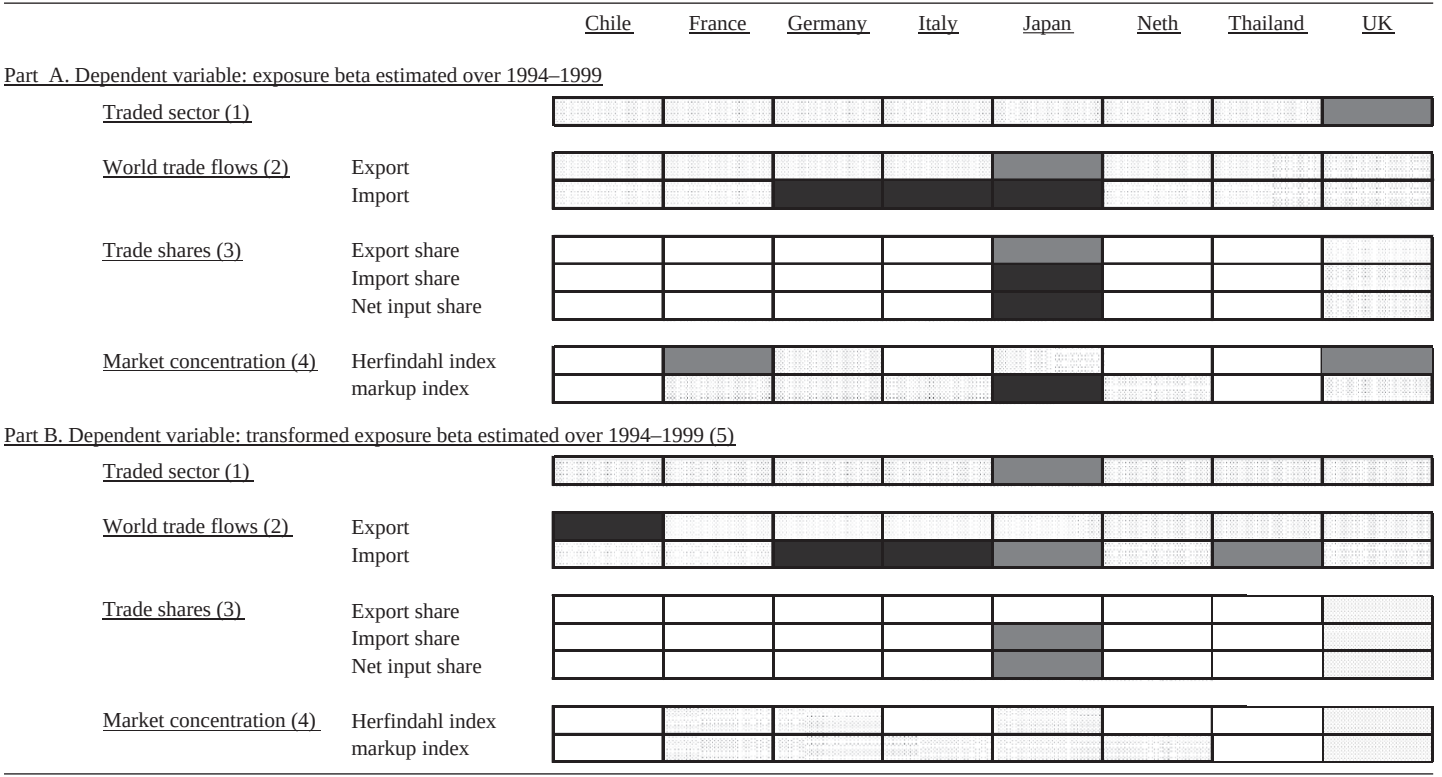

Table 7
Cross-country regression using firm-level exposure US$ betas

| Independent variables | Signed exposure beta (1) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Constant | −0.064* | −0.089* | −0.095 | −0.051 | 0.074 | −0.034 | −0.015 |
| Multinational status | 0.168** | | | | | | |
| Foreign sales | | 0.002** | | | | | |
| International assets | | | 0.006** | | | | |
| Herfindahl index | | | | 0.001** | | | |
| Mark-up index | | | | | −0.088 | | |
| Exports | | | | | | 0.006** | |
| Imports | | | | | | | −0.771** |
| Country fixed effects(3) | | | | | | | |
| Chile | na | 0.184 | 0.283 | na | na | 0.155* | 0.152* |
| Germany | 0.025 | −0.014 | −0.015 | 0.069 | 0.035 | 0.023 | 0.031 |
| Italy | 0.070* | 0.016 | 0.106 | na | 0.015 | 0.016 | 0.047 |
| Japan | −0.025 | −0.001 | −0.004 | −0.042 | −0.020 | −0.079* | −0.048 |
| Netherlands | 0.137** | 0.042 | 0.189 | na | 0.161* | 0.131* | 0.131* |
| Thailand | na | 0.070 | −0.071 | na | na | −0.133* | −0.094 |
| UK | −0.018 | 0.025 | −0.021 | 0.057 | 0.065 | 0.037 | 0.054 |
| Number of observation | 1786 | 1443 | 1054 | 643 | 635 | 1122 | 1122 |
| Adjusted $R^2$ | 0.028 | 0.032 | 0.043 | 0.021 | 0.006 | 0.027 | 0.023 |

| Independent variables | Transformed beta (2) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Constant | 0.471** | 0.446** | 0.462** | 0.446** | 0.501** | 0.457** | 0.447** |
| Multinational status | 0.024 | | | | | | |
| Foreign sales | | −0.000 | | | | | |
| International assets | | | 0.001 | | | | |
| Herfindahl index | | | | 0.001 | | | |
| Mark-up index | | | | | −0.036 | | |
| Exports | | | | | | −0.001 | |
| Imports | | | | | | | 0.179 |
| Country fixed effects(3) | | | | | | | |
| Chile | na | 0.227* | 0.163 | na | na | 0.099** | 0.099** |
| Germany | −0.022 | −0.126 | −0.029 | 0.018 | 0.023 | 0.015 | 0.014 |
| Italy | −0.38 | −0.027 | −0.026 | na | −0.026 | −0.018 | −0.024 |
| Japan | 0.005 | 0.034 | 0.014 | 0.038 | 0.025 | 0.039 | 0.032 |
| Netherlands | −0.011 | −0.003 | 0.052 | na | −0.028 | 0.015 | 0.015 |
| Thailand | na | 0.162** | 0.138** | na | na | 0.161** | 0.152** |
| UK | 0.035 | 0.031 | 0.002 | 0.054 | 0.079* | 0.051 | 0.047 |
| Number of observation | 1786 | 1443 | 1054 | 643 | 635 | 1122 | 1122 |
| Adjusted $R^2$ | 0.006 | 0.053 | 0.038 | 0.004 | 0.009 | 0.038 | 0.038 |

The table shows the results from a pooled regression of exposure betas in the eight countries on dummies for each firm's multinational status, foreign sales, international assets, industry-level Herfindahl index, industry-level mark-up index, industry-level exports and imports, and country fixed effects.
(1) Dollar exposure betas are estimated over 1994–1999.
(2) Transformed beta is the square root of the absolute value of the exposure beta.
(3) Reference country for creating country fixed effects is France.

Our analysis of exposure suggests both that exchange rates have measurable effects on firms, and that firms adjust their behavior in response to exchange rate risk. Further, our results suggest that estimates of exchange rate exposure using industry-level data, or specific subsamples of firms that are "most likely" to be exposed, may well be biased downward, in that exposure seems not to be concentrated in specific industries and firms that are most susceptible to exposure are likely to actively hedge those risks.

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## Appendix A

Table A1
List of industries and dummy variable groupings

| Industry label | Datastream 4-digit level | Datastream 2-digit level | Traded non-traded | World Trade Flows Bilateral Trade Shares BEA categories |
|---|---|---|---|---|
| Mining | 4 | IND00 | Traded | |
| Oil and Gas | 7 | | | |
| Chemicals | 11 | IND10 | | 12,13,14 |
| Construction and Building Materials | 13 | | | 32 |
| Forestry and Paper | 15 | | | 7,8,9,30 |
| Steel and Other metals | 18 | | | 17,18,19 |
| Aerospace and Defense | 21 | IND20 | | 29 |
| Diversified Industrials | 24 | | | 31,33 |
| Electronic and Electrical Equipment | 25 | | | 22,25,26,27 |
| Engineering and machinery | 26 | | | 20,21,23 |
| Automobiles | 31 | IND30 | | 15,28 |
| Household Goods and Textiles | 34 | | | 5,6,24,34 |
| Beverages | 41 | IND40 | | 2 |
| Food Producers and Processors | 43 | | | 1,4 |
| Health | 44 | | | |
| Packaging | 46 | | | 16 |

(continued on next page)

Table A1 (*continued*)

| Industry Label | Datastream 4-digit level | Datastream 2-digit level | Traded non-traded | World Trade Flows Bilateral Trade Shares BEA categories |
|---|---|---|---|---|
| Personal Care and Household Products | 47 | | | 11 |
| Pharmaceuticals | 48 | | | 10 |
| Tobacco | 49 | | | 3 |
| Distributors | 51 | IND50 | non-traded | |
| Retailers, General | 52 | | | |
| Leisure, Entertainment and Hotel | 53 | | | |
| Media and Photography | 54 | | | |
| Restaurants, Pubs, Breweries | 56 | | | |
| Support Services | 58 | | | |
| Transport | 59 | | | |
| Food and Drug Retailers | 63 | IND60 | | |
| Telecom Services | 67 | | | |
| Electricity | 72 | IND70 | | |
| Gas | 73 | | | |
| Water | 78 | | | |
| Banks | 81 | IND80 | | |
| Insurance | 83 | | | |
| Life Assurance | 84 | | | |
| Investment companies | 85 | | | |
| Real Estate | 86 | | | |
| Specialty and other Finance | 87 | | | |
| Information Technology Hardware | 93 | IND90 | | |
| Software and Computer Services | 97 | | | |

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