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Abstract: This paper examines if the type of exchange rate used or size of the movement in the exchange rate matters in estimating exchange-rate exposure of U.S. nonfinancial multinationals. We find that switching from a broad trade-weighted exchange rate to a 2-digit SIC industry exchange rate increases the number of significantly exposed firms in a simple Jorion (1990) regression by 60 percent. Then separating crisis from non-crisis months we find additional evidence of exposure. Although the value of exposure does not change with the size of the exchange rate movement, we find some firms have significant exposure only in crisis periods while others have significant exposure only during normal fluctuations in exchange rates. All told, we find about 1 in 4 firms' returns is significantly affected by movement in the exchange rate between 1995 and 1999.

Keywords: exposure, crisis indicators, 2-digit SIC industry exchange rate
JEL codes: F23, F31, G120

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Introduction

Estimating exchange-rate exposure began with the simple Jorion model in 1990 and evolved to more sophisticated time-varying models early this decade (e.g., Allayannis and Ihrig (2001) or Bodnar, Dumas and Marston(2002)). In all of these studies, although the question was how does movement in the exchange rate affect the firm's return, no one stepped back and examined whether the type of exchange rate used in the analysis mattered or if the size of the movement in the exchange rate mattered. Here we answer these two questions, focusing on monthly U.S. manufacturing multinational (MNE) data between 1995 and 1999.

We begin by examining the exchange rate measure. Past studies of U.S. firms used a broad U.S. trade-weighted exchange rate. This exchange rate captures the trade flows of the United States, as a whole, but does not necessarily reflect the foreign currency exposure of any given firm. Here we replace the broad U.S. dollar with 2-digit SIC industry exchange rates.[1] Utilizing 2-digit trade shares from Goldberg (2001), we construct monthly 2-digit SIC industry trade-weighted exchange rates. Using these exchange rates in the simple Jorion (1990) model, where the broad U.S. dollar found only 10 percent of the firms with significant exposure, we find the number of U.S. MNEs' with significant exposure rises to 17 percent.

Next we turn to the issue of whether the size of the movement in the exchange rate matters in the estimate of exposure. There are many reasons why exposure can differ between periods of normal exchange rate fluctuations and crises periods. During an exchange-rate crisis,

[1]Ihrig (2001) constructs MNE-specific exchange rates by weighting bilateral exchange rates by the number of subsidiaries of an MNE located in a given country. The drawback of this measure is that the weights are based on number of subsidiaries, not sales or revenue of the subsidiaries, so we focus on the 2-digit SIC industry trade-weighted measure in this paper. See Ihrig (2001) for details of the subsidiary-weighted exchange rate results.

for example, hedging opportunities might be limited and/or the firm may see a sudden change in revenue and/or costs, all of which affect the value of exposure.[2] We test for the possibility that exposure varies with the evolution of a crisis: there is a 'normal' value of exposure associated with 'normal' movements in the exchange rate, and a different value of exposure during periods of stress in the exchange rate market.[3]

Using crisis dates from the early warning system literature (e.g., Kaminsky, Lizondo, and Reinhart (1998)) we construct 2-digit SIC trade-weighted crisis dummies. Incorporating these crisis dates into the exposure model we find that 14 percent of the firms have significant exposure during periods of normal movement in the exchange rate and 10 percent of the firms have significant exposure during crisis periods. Some firms' returns may have significant exposure in one states, but not both. Overall, 23 percent of the firms are affected by exchange rate movement in at least one of the two states.

We find that the value of exposure does not differ across states of exchange rate fluctuations.[4] On average, across all firms, the median estimate of exposure is -0.47. Of course, the effect of exchange rate movement on returns is influenced by the size of the exchange rate movement. During normal monthly fluctuations in the exchange rate, which averaged 4/10th of a percentage point appreciation of the dollar per month between 1995 and 1999, we find monthly

[2]See Allayannis, Brown and Klapper (2002) for more details of derivatives market illiquidity during the East Asian crisis, and Allayannis and Ihrig (2002) for details of how revenue and costs affect exposure.

[3]We also tested for the possibility that there was overshooting during the crisis period, so that exposure bounced back immediately following a crisis (as expectations realigned). We did not find support for this hypothesis.

[4]This finding differs from Kiymaz (2003) who finds Turkish firms' exposure is higher in pre-crisis than post-crisis periods.

returns fell by 0.2 percentage points due to the appreciation of the dollar. During a crisis, where the dollar appreciated 0.8 percent per month, we estimate monthly returns fell by 0.4 percentage point during a crisis month. Focusing solely on the significantly exposed MNEs, the median estimate of exposure triples to -1.39. This indicates that during normal exchange rate fluctuations returns fell, on average, 0.55 percentage points per month, and in a crisis period the average return fell by 1.1 percentage points.

Our findings are consistent with other research that examines how firm activity is affected by crisis episodes. Forbes (2002) documents how firms in 41 countries have their annual performance (measured as firm sales, net income, market capitalization and asset value) negatively affected over the span of exchange rate crises. Allayannis and Weston (2002) document monthly abnormally low returns of U.S. MNEs from the East Asian crisis. Forbes (2001) estimates abnormally low returns of 15 (10) percentage points through the duration of the Asian (Russian) crisis. Each of these studies supports the results found here.

Comparing across crisis and non-crisis periods, many firms that had significant exposure in crisis periods did not have significant exposure in non-crisis months, suggesting that these firms might have been able to hedge small movement in exchange rates, but could not insulate their cashflow from crisis episodes. This result is consistent with Chow, Lee and Solt (1997) who argue changes in the exchange rate affect short-term and long-term cashflows, but current exchange-rate changes can be hedged or the cashflow effects are offset by interest-rate effects. Since the firms that have significant exposure only in crises, which are periods hedges may not be available, Chow's comments hold. However, we also find just as many firms that have significant exposure during periods of normal movement in the exchange rate and not in crisis

months. This contradicts Chow et al.'s hypothesis. Perhaps these firms do not hedge for cost/benefit reasons, and during periods of large fluctuations in foreign currency they expend the energy to operationally hedge. For example, Schering-Plough in its 1995 annual report (page 25) argues in support of exclusive use of operational hedges: "To date, management has not deemed it cost-effective to engage in a formula-based program of hedging the profitability of these operations using derivative financial instruments. Some of the reasons for this conclusion are: The Company operates in a large number of foreign countries; the currencies of these countries generally do not move in the same direction at the same time".

We perform sensitivity analysis on the results, using alternative crises indicators and MNE-specific weighting schemes. Whether we change the weighing scheme or early warning system crisis measure our results still hold: we find a large increase in the number of firms with significant exposure when we switch to a more firm-specific exchange rate, and the number of firms with significant exposure increases when we account for different sizes of exchange rate movement.

The remainder of this paper is organized as follows. Section 1 describes the model. Section 2 overviews the data, while section 3 presents the exposure estimates. Section 4 concludes the paper.

I. Model

We estimate a modified Jorion (1990) model. For each MNE, exchange-rate exposure is estimated by regressing the MNE's return on the market return and exchange rate movement, accounting for periods of exchange rate crises. Specifically,

$$R_t^i = \alpha_0^i + \alpha_1^i R_t^m + \beta_1^i \Delta e_t + \beta_2^i I_t \Delta e_t + \varepsilon_t^i \qquad (1)$$

where R^i is firm i's return at date t, R^m is the market return, Δe is the change in the exchange rate, and I is the crisis indicator that is nonzero in a month where there is a crisis.

The structural adjustment to the Jorion model is the inclusion of the I term. In Jorion's framework exposure is β^i_1. In our framework exposure is $\beta^i_1 + \beta^i_2 * I^i_t$. Exposure varies though time as I fluctuates between zero and one. Compared to other recent estimates of exposure (such as in Allayannis and Ihrig (2001) and Bodnar et al. (2002), we are implicitly embedding the effects of trade shares, markups and pass-through in our β's. As shown in this past work, one can find more firms with significant exposure by accounting for these features of the data, so we keep in mind that our results may be a lower bound for the actual number of firms' returns significantly affected by exposure when accounting for the effect of a crisis.

II. Data

In our analysis we estimate monthly time-varying exchange rate exposure for 164 U.S. manufacturing multinationals in exchange rate crisis and non-crisis months between 1995 and 1999. First we discuss the specifics of the data sources and how we constructed key variables for the analysis. Then we provide some summary statistics.

II.A Data construction and sources

The data for this project mixes the standard return variables with new exchange rate data. The exchange rate data is unique in two respects. First, we use an exchange rate measures more specific to the MNEs by utilizing monthly 2-digit SIC industry series. Second, we introduce an exchange rate crisis variable in the model to allow for crisis periods to differ from non-crisis months. The sample contains monthly data on 164 MNEs. Exposure is estimated over the 5-year interval 1995-1999, so that there are 9840 firm-year observations in the sample. This time period is chosen for two reasons. First it incorporates a period with many crises. Over this period Brazil, Colombia, Indonesia, South Korea, Malaysia, the Philippines, Singapore, South Africa, Spain, Thailand, and Venezuela were flagged by the early warning system indicators as having a crisis.[5] Second, for sensitivity analysis, we compare the SIC weighted results to Ihrig (2001) that has subsidiary-weighted results using data on the location and number of level-1 subsidiaries from the National Registry centered in 1997.

Returns: Monthly manufacturing MNE returns were retrieved from the University of Chicago Center for Research in Security Prices (CRSP) database. Dividends are included in the prices used to calculate firm returns. The CRSP monthly value-weighted market index is used as the market portfolio.

[5]This list is based on the Kaminsky, Lizondo, and Reinhart (1998) measure of an exchange-rate crisis. Other countries may have been flagged as crisis countries, but were excluded from the sample because of their low trade weight.

SIC classification: CRSP firm data was matched with a SIC industry using Bloomberg. Bloomberg estimates a single SIC for each firm by referencing companies registration statements with the SEC and sales data. Our sample contains firms in SIC industries 20-39, excluding 24 and 31.

Exchange rate: As a reference exchange rate, we consider the JPMorgan Broad exchange rate index. This "broad" type of exchange rate is consistent with what is used in most other studies of exposure (e.g. Jorion, Allayannis and Ihrig, Bodnar, Dumas and Marston). For this analysis, however, we focus on 2-digit SIC industry exchange rates. Using the trade shares from Goldberg (2001), the monthly 2-digit SIC industry exchange rate for industry i is defined as:

$$e_i = \sum_{j=1}^{N} w_{i,j} ER_j$$

where N is the total number of countries that this industry trades with, $w_{i,j}$ is the percent of trade between the U.S. and country j in industry i, and ER_j is the bilateral exchange rate between the U.S. dollar and the currency of country j. All firms within a given 2-digit classification will have the same exchange rate.[6] Although this exchange rate measure is not firm specific, it does more accurately reflect the currencies that are important to the firm's industry than the broad dollar measure. Across all firms in our sample, the correlation between movement in the 2-digit exchange rate series and the JPMorgan Broad is 0.73. The correlation varied from 0.37 for SIC 29 (petroleum and coal products) to 0.98 for SIC 38 (instruments).

[6]So this exchange rate measure is not firm specific. Ihrig (2001) creates firm-specific exchange rates by looking at subsidiary locations.

Crisis indicators: Associated with the early warning system literature, various measure of exchange rate dating have emerged. Our primary measure is Kaminsky, Lizondo, and Reinhart (KLR) (1998), however, we also do sensitivity analysis with Frankel and Rose (1996) and Kamin, Schindler and Samuel (2001). Each of the three studies creates monthly country indicators that take on values of zero or one.[7] A zero means that there is no exchange-rate crisis in the country at that date. A one indicates that, based on the authors' criteria, there was above normal exchange rate pressure (i.e., a crisis). Edison (2000) provides a good overview of the research on the early warning systems and, extends the indicators in the earlier studies through the 1990s.

We take the KLR country crisis indicators and create our 2-digit SIC industry's trade-weighted crisis dummy variable as follows:

$$I_i = \sum_{j=1}^{N} w_{i,j} CRISIS_j$$

where N is the total number of countries that this industry trades with, $w_{i,j}$ is the percent of trade between the U.S. and country j in industry i, and $CRISIS_j$ is the crisis indicator (KLR) of country j. I can take on a value between zero and one. If none (all) of the countries where this 2-digit SIC industry has trade flows had a crisis, then I is zero (one).

Since all of our 2-digit SIC industry crises measures are created from the same set of N countries, and no trade-weights are zero, all firms experience the same set of crises. Over our five-year sample period, all industries encountered 51 months without crises, and 9 months with

[7]The three indicators differ in the variables they use to identify periods of greater than normal exchange-rate pressure. Kaminsky et al. define a crisis by large movement in the nominal exchange rate and/or international reserves.

crises. Of course, the value of I depends on the percent of trade in the crises countries. Across all industries and all months, the average value of I is 0.0024 (which reflects the fact that 51 months of our sample see I take on a value of zero). During crises months, the average value of the crises indicator is 0.016, indicating that about 1.6 percent of trade, on average, is with crises countries. Looking across industries in crises months, I ranges from an average value of 0.009 in industry 37 (transportation equipment) to 0.037 in industry 29 (petroleum and coal products).

II.B. Glance at the data

The exchange rates and crisis dummies we construct use the 2-digit SIC industry trade weights. In an attempt to reveal how these variables are affected by the trade shares, consider SIC 26 - paper and allied products. This industry has 10 firms in our sample (of which we find 4 had significant exposure).

Figure 1 plots the crisis measure, I, for SIC 26 over our sample period. This provides an illustration of how often and how much of the paper industry's operations are located in crisis countries. Recall that the crisis dummy, I, takes on a value between zero (no trade in countries with a crisis) and one (all trade is with countries that are having a crisis). There are 9 months that the indicator flags as the industry having trade with countries in crisis. In the crisis months, on average, 1.3 percent of trade is associated with crisis countries. The first crisis month is 1995:3, when the central bank of Spain devalued the peseta by 7 percent. The value of I is 0.01, representing Spain's trade share of 1 percent. The larger spikes found in 1997:11, 1997:12 and 1999:1 are associated with crises in South Korea (2.5 percent of trade is with South Korea), the

East Asian countries of Indonesia (0.7 percent), Phillippines (0.4 percent) and Singapore (0.5 percent), and Brazil (2.4 percent), respectively.

Figure 2 plots the JPMorgan's Broad exchange rate, the series typically used in exposure analysis, and the exchange rate for SIC 26. These two series have a correlation of 0.73. Beginning with the 1995:3 crisis, you can see the SIC 26 exchange rate shows a dollar appreciation (reflecting the depreciation of the peseta), but the Broad dollar actually depreciates, reflecting appreciations of other foreign currencies that the broad dollar puts more weight on than SIC 26. Moving to 1997, you can see the JPMorgan Broad and SIC 26's exchange rates move in parallel, both picking up the crisis at the same time and with about the same magnitude. In 1999, SIC 26 picks up the Brazilian crisis slightly earlier and slightly larger in magnitude than the JPMorgan Broad dollar. So we can see differences in the exchange rate measures resulting from differences in the amount of trade with foreign countries.

Table 1 provides summary statistics of all the variables we use in the analysis. Column 1 reports the average value over the entire sample, column 2 reports the means for crisis periods ($I \neq 0$) and column 3 reports the average value in non-crisis months ($I=0$). Starting with the returns, we see that returns are actually higher in exchange-rate crises months than non-crises months. Of course, there are many variables affecting returns (including interest rates, which respond to currency crises and affect the rate of return) so what is really important to us is the difference between the firm's return and the market return. As seen in the third row, R^i-R^m, the difference between the MNE's return and the market return increases during crises months from -0.4 percentage points in non-crises months to -1.2 percentage points in crisis months. The next row highlights that the average U.S. dollar appreciation over the whole sample (across all 2-digit

SIC industry exchange rates) is 0.4 percent per month, with crisis months having an appreciation of 0.9 percent. Last, the average value of the crisis dummy is quite small, at 0.003 over the entire sample.

We now turn to the estimated model.

IV. Exposure Estimates

To begin, we run the standard Jorion (1990) regression using the JPMorgan broad exchange rate and the appropriate SIC-specific exchange rate for each of the 164 firms over 1995:1-1999:12. A summary of the exposure estimates is presented in Table 2. Column 1 reports the results using the JPMorgan Broad exchange rate; we find the standard Jorion result that about 10 percent of the firms' returns are affected by exchange rate movement. The median exposure is -0.30, which translates to a one percent appreciation of the dollar causes monthly returns to fall, on average, by 0.03 percentage points. This estimate is in line with Jorioin's findings. Column 2 reports the results using the 2-digit SIC industry exchange rates. We find that the number of firms with significant exposure rises to 17 percent of the sample and the median exposure is -0.42. Hence, switching to the more firm-specific exchange rate causes the number of firms with significant exposure to rise, and remember this is a very simple model abstracting from trade shares, markups and pass-through, which when incorporated into past models generated a rise in significant exposure.

Next we move to estimating exposure in our model that accounts for exchange-rate crises, equation (1). Exposure is calculated as $\beta^i_1 + \beta^i_2 * I^i_t$. Table 3 reports summary statistics on the values of β_1 in column (1) and β_2 in column 2 for all firms in the sample. As shown, 24 firms

have significant exposure under normal fluctuations in the exchange rate. Sixteen firms had significant exposure during crisis months. Only 3 firms have significant exposure in both exchange-rate states, hence 37 firms have significant exposure in at least one of the two exchange-rate states, indicating 23 percent of the firms in our sample have significant exchange-rate exposure.[8]

The little overlap in the number of firms that have significant exposure during normal periods of exchange rate fluctuation and crisis periods can be interpreted as follows. Firms with significant exposure during a crisis, but not in normal months, could be using exchange rate hedges in normal states but that these hedging opportunities are not available during crises. For those firms that see their returns affected by small exchange rate movements but not during crises, perhaps they are not hedging for cost/benefit reasons, but take the time to operationally hedge large fluctuations in the U.S. dollar.

Turning to the estimated value of exposure, column 3 reports summary statistics. The median value is -0.47, close to the median value when there are normal fluctuations in the exchange rate (because the value of I during crisis periods only averages 0.016). Note that the movement in the exchange rate is much larger in a crisis than a non-crisis period, so the effect of the exchange rate on returns is much more prominent during a crisis. That is, on average, the dollar appreciates 8 percent per month during the crisis months of our sample, so the median firm's return falls by 0.38 percentage points per month due to the movement in the exchange rate. This is slightly more than twice as large as the effect of the exchange rate movement on a

[8]As shown in other work, including more firm-specific attributes in the estimation equation can lead to even more evidence of exposure, so we treat the finding that 23 percent of the sample had significant exposure as a lower bound.

firm's return in non-crisis months (because the dollar appreciated, on average, by 0.3 percent per month).

Looking at only those firms with significant exposure, reported in columns 4-6, the median value of exposure is three times as large as what is found over all firms in our sample. Exposure jumps to -1.39, suggesting larger declines in the significant firm's returns during crisis periods than the average firm in our sample. The median significant firm's return falls by 1.1 percentage points in a crisis month.

Figure 3 highlights a significantly exposed firm in our sample: Kimberly-Clark Corporation (KMB) in SIC 26 (exchange rate and crisis dummy variables highlighted in Figures 1 and 2). The figure plots $R^i - R^m$ for KMB. You can see that in 6 of the 9 months identified as a crisis month (when I is nonzero), $R^i - R^m$ was negative. Specifically, looking at 1995:3, when the peseta devalued, the spread between KMB and the market return widened. This was also the case through the East Asian crisis in 1997 and the Brazilian crisis in 1999:1. On average, in crisis periods the spread was -1.2 percentage points (coincidentally, the same as the average spread across all firms in crisis months, see Table 1, column 2).

Looking across SICs, we find 13 of the 18 SIC industries have firms with significant exposure. Figure 4 shows the distribution of firms across industries, both total number of firms in the industry and the number of significantly exposed firms. As seen, SICs 25 (furniture and fixtures), 22 (textile mill products), 26 (paper and allied products), 35 (industrial machinery and equipment), 34 (fabricated metal products) and 30 (rubber and miscellaneous plastic products) all have more than a third of their firms with significant exposure. This is in stark contrast with

SIC 36 (electrical and electronic equipment) that has no firm with significant exposure, even though it has quite a few firms in our total sample.

Last we test the sensitivity of our analysis to different crisis indicators and MNE specific-exchange rates.[9] Each sensitivity analysis suggests the results are robust. That is, the more firm-specific exchange rate used in estimating exposure, the more firms one finds with significant exposure. The value of exposure is not sensitive to the size of the fluctuation in the exchange rate, but some firms' returns are affected by normal fluctuations in the exchange rate, while others are affected by large movement in the exchange rate. The value of exposure does vary by firm and is three time as large for firms with significant exposure. Overall, approximately one in four U.S. MNEs has significant exchange-rate exposure.

IV. Conclusion

This paper took the standard Jorion (1990) model for estimating exposure and adapted it to incorporate two specific exchange-rate issues. First we introduced a more firm-specific exchange rate in the analysis. Second, we adjusted the model to allow exposure to differ between periods of normal exchange rate fluctuations and during crises. These two simple modifications suggest that exposure is much more prevalent than the Jorion (1990) estimates suggested.

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[9]Ihrig (2001) reports results using an MNE-specific exchange rate, where the weights are the number of U.S. MNE's subsidiaries located in a given country relative to the total number of subsidiaries of the MNE. The results are similar to what is reported here; however, since the subsidiary weighting seems inferior to the 2-digit SIC weighting these results are not reported here.

Estimation results suggest that almost 1 out of every 4 U.S. nonfinancial MNEs had significant exchange rate exposure between 1995 and 1999. On average, exposure is estimated to be near -0.5 across all firms in our sample and almost three times as large for firms significantly affected by exchange rate movements. The estimate of exposure does not depend on the size of the exchange rate movement. But, the effect of the exchange rate movement on the firm's return, of course, does depends on the size of the movement. During crisis periods, the effect on returns was quite large. Significant firms saw their return fall by an average of 1.1 percentage points in a crisis month.

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Table 1 - Summary Statistics

	All months (1)	Crisis months (2)	Non-crisis months (3)
R^m	2.1	*3.3*	*1.8*
R^i	1.6	*2.1*	*1.4*
R^i-R^m	-0.5	*-1.2*	*-0.4*
Δe	0.4	*0.8*	*0.3*
I	0.003	0.018	0
Observations	9840	*2923 (actually 1462)*	*6917 (actually 8295)*

Table 2 - Exposure Estimates using Standard Jorion model, 1995:1-1999:12

$R_t^i = \alpha_0^i + \alpha_1^i R_t^m + \beta^i \Delta e_t + \varepsilon_t^i$

	JPMorgan Broad (1)	2-digit SIC exchange rate (2)
Minimum	-3.99	-3.37
First Quartile	-0.91	-1.11
Median	-0.30	-0.42
Third Quartile	0.22	0.09
Maximum	1.80	1.96
# Significant @ 10%	17	28
Median Exposure	-0.30	-0.42
# MNEs	164	164

Note: values reported in the table are the estimates of exposure from the standard Jorion model, β

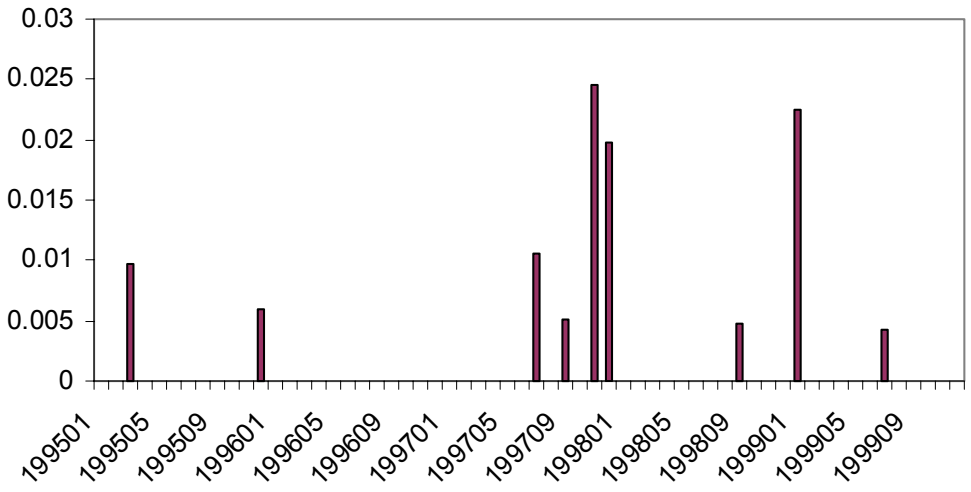
Table 3 - Estimating Exposure with a Crisis Dummy, 1995:1-1999:12

$$R_t^i = \alpha_0^i + \alpha_1^i R_t^m + \beta_1^i \Delta e_t + \beta_2^i I_t \Delta e_t + \varepsilon_t^i$$

	All firms			Significantly Exposed Firms		
	β^i_1 (1)	β^i_2 (2)	$\beta^i_1 + \beta^i_2 * I^i_t$ (3)	β^i_1 (4)	β^i_2 (5)	$\beta^i_1 + \beta^i_2 * I^i_t$ (6)
Minimum	-3.88	-738.86	-3.79	-3.88	-227.19	-3.79
First Quartile	-1.18	-24.65	-1.11	-2.13	-2.15	-2.09
Median	-0.45	7.56	-0.47	-1.53	21.90	-1.39
Third Quartile	.0..	40.89	0.04	-1.13	96.68	-0.89
Maximum	1.99	371.78	1.97	1.83	371.78	1.88
# Significant @ 10%	24	16	37	24	16	37
Median Exposure						
# MNEs	164	164	164	37	37	37

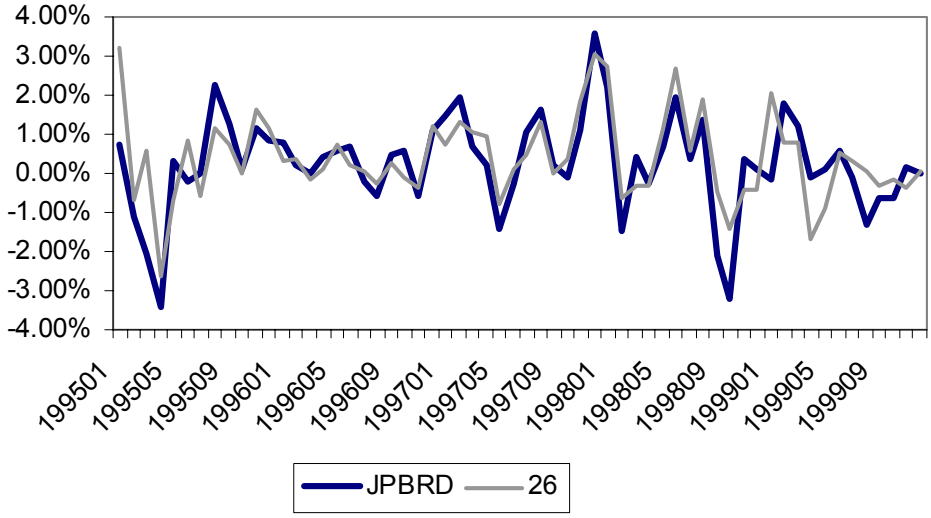
Note: Exposure is $\beta^i_1 + \beta^i_2 * I^i_t$ and estimated using equation (1).

Figure 1 - Crisis Dummy for SIC 26 (Paper and allied products)



Note: I∈[0,], 0 indicates no trade with crises countries.

Figure 2 - Movement in the Broad dollar versus SIC 26 exchange rate



Notes: Positive numbers represent U.S. dollar appreciations.
Correlation between series is 0.73

Figure 3 - Significantly Exposed firm in SIC 26

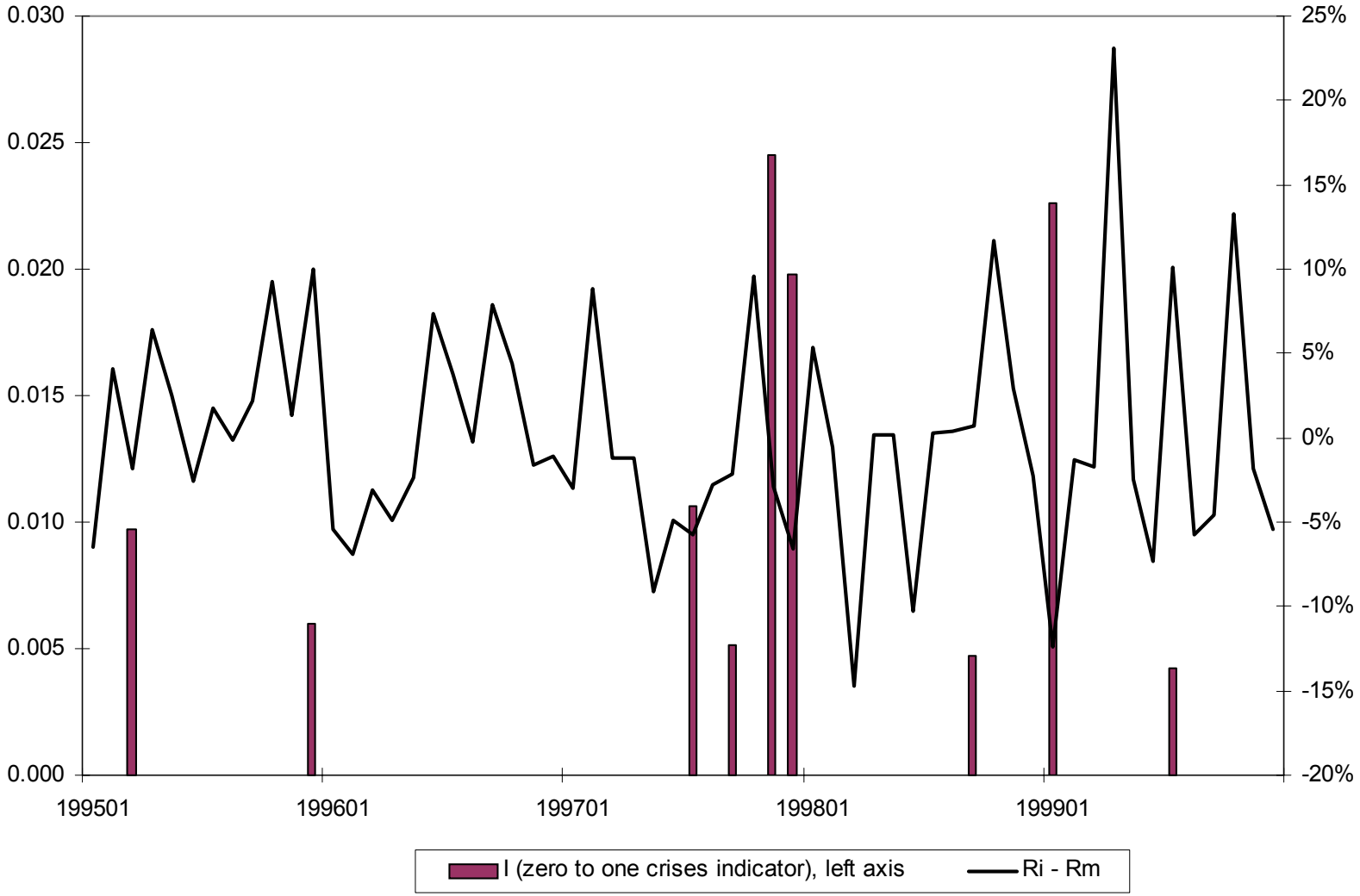


Figure 4 - Distribution of firms across industries