The Impact of the Introduction of the Euro on Foreign Exchange Rate Risk Exposures

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Abstract

This paper examines whether the introduction of the Euro in 1999 was associated with lower stock return volatility, market risk exposures and foreign exchange rate risk exposures for 12,821 nonfinancial firms in Europe, the United States, and Japan. We show that though the Euro led to a significant decrease in the volatility of trade-weighted exchange rates of European countries, stock return variances of nonfinancial firms increased after its introduction. However, the Euro was also accompanied by significant reductions in market risk exposures for nonfinancial firms in and outside of Europe. We show that the reduction in market risk was not as a result of changes in financial leverage, and that it is concentrated in firms with a high fraction of foreign sales in Europe, a high fraction of total foreign sales and larger market capitalizations. In addition to its impact on market betas, the Euro has a positive effect on the incremental foreign exchange rate exposures, particularly for multinationals.

Keywords: Foreign exchange rates, exposure, Euro, corporate finance, risk management, derivatives

JEL Classification: G3, F4, F3

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This paper examines whether the introduction of the Euro in 1999 was associated with lower stock return volatility, market risk exposures and foreign exchange rate risk exposures for 12,821 nonfinancial firms in Europe, the United States, and Japan. We show that though the Euro led to a significant decrease in the volatility of trade-weighted exchange rates of European countries, stock return variances of nonfinancial firms increased after its introduction. However, the Euro was also accompanied by significant reductions in market risk exposures for nonfinancial firms in and outside of Europe. We show that the reduction in market risk was not as a result of changes in financial leverage, and that it is concentrated in firms with a high fraction of foreign sales in Europe, a high fraction of total foreign sales and larger market capitalizations. In addition to its impact on market betas, the Euro has a positive effect on the incremental foreign exchange rate exposures, particularly for multinationals.

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"For businesses, a common currency will reduce transactions costs – eliminating, among other things, the unnecessary waste of resources involved in dealing with several European currencies. At present, doing business across borders means having to buy and to sell foreign currencies – and taking the risk that sudden changes in their relative value could upend an otherwise sound business strategy. They can be hedged, of course, but only at a cost that must ultimately be borne by the customers."

Jürgen Schrempp, CEO of DaimerChrysler AG
(Newsweek Special Issue 9/1998-2/1999)

1 Motivation

To date, academic studies have had limited success in empirically identifying significant exposures of nonfinancial firms with regard to unexpected changes in exchange rates (Bodnar and Wong, 2003; Griffin and Stulz, 2001; He and Ng, 1998; Bartov, Bodnar and Kaul, 1996; Prasad and Rajan, 1995; Bartov and Bodnar, 1994). Since financial theory predicts, however, that firm value should be affected by foreign exchange rate risk (Levi, 1996; Shapiro, 1974; Dufey, 1972), the apparent discrepancy between theoretical hypotheses and the existing empirical evidence of over 60 studies is still perceived as an unsolved issue in the finance literature.

This paper takes a new look at the exposure puzzle by studying the potential impact of the introduction of the Euro. The introduction of the Euro as a common currency in January 1999 is an important historical event and one that provides a useful experimental setting to investigate the foreign exchange rate exposure phenomenon. As a matter of fact, a popular argument in favor of a common European currency has been the reduction of foreign exchange rate risk that would benefit European firms in general and corporations with significant trade or investments in Europe in particular. Consequently, this paper performs a firm-level analysis of changes in overall stock return volatility and its components related to market risk and foreign exchange rate risk and how they are different for firms according to the scope of their economic activity globally and in the Euro area, in particular.

To this end, this paper benefits from a high degree of detail on geographic segment sales data provided by OSIRIS© (Bureau Van Dijk Publishing), a comprehensive database of 31,000 listed companies in 125 countries. The primary advantage of OSIRIS is that it reports much richer segment data per firm than

other databases. To illustrate, OSIRIS has seven times as many geographic segments for firms in Europe, four times as many for Japanese firms and three times as many for U.S. firms than the Worldscope database that is commonly used for international studies. Moreover, OSIRIS also covers a larger number of firms in Europe, which is the focus of the investigation. While this data has not been used to study foreign exchange rate exposures yet, the pattern of geographic segment sales is economically a crucial determinant of the foreign exchange rate exposure. In particular, since the Euro is introduced in a specific set of European countries only, firms with foreign activities in these countries are expected to be affected differently by the introduction of the Euro than other firms, and foreign sales in the Euro countries proxy for this Euro currency exposure. While the Euro has not been subject to exposure studies yet, the results of this paper lend themselves for a comparison with the findings by Bartov, Bodnar and Kaul (1996) who study an event with the opposite effect: the introduction of flexible exchange rates after the breakdown of the Bretton Woods System.

The empirical investigation in this paper includes a total of 12,821 firms in Europe, the United States of America, and Japan, and thus represents one of the largest and broadest studies of foreign exchange rate exposures. The analysis documents that the Euro leads to a substantial reduction in the volatility of trade-weighted exchange rate indices of European countries. At the same time, stock return variances of nonfinancial firms increase during the sample period, but the increase is lower for European firms with a high fraction of foreign sales in the Euro area or high foreign sales in general. The results further indicate the importance of decomposing total stock return volatility into components of systematic and diversifiable risk (Bodnar and Wong, 2003). In particular, the introduction of the Euro is associated with a significant reduction in market risk and lower foreign exchange rate risk for firms in and outside of Europe. This finding suggests that foreign exchange rate risk is an important component of systematic risk. The reduction in market risk is significantly stronger for firms that are more exposed to Euro area currency risk due to higher percentages of foreign sales in this region, that have higher percentages of total foreign sales and that are larger in market capitalization. Moreover, the Euro has a positive effect on the

incremental foreign exchange rate exposures, particularly for multinationals. While the decrease in market risk could in principle also result from changes in financial leverage, the evidence does not support this alternative explanation.

The strong results for changes in market betas associated with changes in exchange rate risk indicate a potential conceptual problem in the traditional approach of estimating exchange rate exposures. Empirical exposure studies typically employ regressions of stock returns on returns of a value-weighted (or equally-weighted) market portfolio and an exchange rate factor, computed as innovations in a trade-weighted exchange rate index. The market variable is used as a control variable, and usually the coefficient of the exchange rate variable is interpreted as exchange rate exposure. The results in this paper suggest that the failure to detect significant exchange rate exposures may be the result of the fact that the incremental exchange rate variable only partially captures the effect of exchange rate risk on firm value.

The empirical results have important policy implications as they demonstrate the benefits of currency stabilization for nonfinancial companies around the world. With lower exposures, nonfinancial firms benefit from lower resources committed to corporate risk management and increased potential to carry higher business risk or to sustain more financial leverage. Moreover, reductions in market betas imply reduced cost of capital with concomitant benefits for corporate investment and firm valuations. This result is corroborated by evidence in a recent study of European firms by Bris, Koskinen and Nilsson (2002) that the introduction of the Euro is associated with significant increases in Tobin's q.

The paper is organized as follows. Section 2 reviews the existing empirical evidence on foreign exchange rate exposures of nonfinancial firms. Section 3 discusses the research design and data sources. Empirical results are presented in Section 4. Subsequently, Section 5 offers a discussion of the results and alternative interpretations, while Section 6 concludes.

2 Previous Evidence on Exchange Rate Exposures

Due to the increasing globalization of business activities and at times higher volatility in international financial markets, the management of foreign exchange rate risk has become more important not only for companies in the financial service industry, but also for the large number of nonfinancial firms. According to survey data (Bodnar, Hayt and Marston, 1996, 1998; Bodnar, Hayt, Marston and Smithson, 1995), managers' specific concerns about foreign exchange rate risk relate to the volatility in firm cash flows. Much of the seminal research on corporate exchange rate exposures has similarly examined the impact of exchange rates on cash flow volatility (Shapiro, 1974; Hodder, 1982; Adler and Dumas, 1984; Flood and Lessard, 1986). The theories predict that cash-flow sensitivity to exchange rates should depend on the nature of the firm's activities, such as the extent to which it exports and imports, its involvement in foreign operations, the currency denomination of its competitors and the structure of its input and output markets (Allayannis and Ihrig, 2001). Most of the theoretical justifications for a firm managing its currency risk also come from cash-flow volatility arguments (Smith and Stulz, 1985; Froot, Scharfstein and Stein, 1993; Géczy, Minton and Schrand, 1997), but the complex demand and cost structures of most firms make an exact determination of the magnitude and direction of those exposures very difficult.

Empirical studies have investigated the relationship between exchange rates and firm value in a systematic way since the early 1990s. Typically, these studies follow Adler and Dumas (1984) who define the exposure elasticity as the change in the market value of a firm resulting from a unit change in the exchange rate and who thus recommend a simple regression approach for its measurement. Jorion (1990) provides an important early analysis of 287 U.S. multinational firms and reports that only 15 are significantly affected by exchange rate risk. This counterintuitive empirical result has triggered a large number of studies on foreign exchange rate exposure since, each of which seek alternative approaches and methodologies (Bodnar and Gentry, 1993; Choi and Prasad, 1995; Allayannis and Ofek, 2001; Williamson, 2001). Nevertheless, there is surprisingly weak evidence of statistically significant currency exposures, and also the economic significance of exposures is low (Griffin and Stulz, 2001).

Results for portfolios constructed of firms, say, in the same industry show similar results. For example, 20% and 35% of the industry portfolios in Jorion (1990) and Jorion (1991), respectively, show significant foreign exchange rate exposure. Choi and Prasad (1995) show a significant exposure for 15% of the nonfinancial firms and 10% of the industry portfolios in the United States. Some researchers consider multilateral exchange rate indexes instead of bilateral foreign exchange rates. He and Ng (1998) report a significant foreign exchange rate exposure with regards to a multilateral exchange rate index for 26% and 54% of 171 multinational companies in Japan over different time periods. Return measurement horizon, especially model specification, impact estimates of exposure. Bodnar and Wong (2003) show that increasing the return horizon from 1 to 60 months can increase the precision of firm-level estimates of exposure, but especially when controlling for macroeconomic and market-wide capital-market effects. Some have suggested that the foreign exchange rate exposure may be in part nonlinear and thus not be captured by traditional approaches to estimate foreign exchange rate exposures. Bartram (2003) argues that this may be due to corporate cash flows being a nonlinear function of foreign exchange rates, real or financial options at the firm level or the result of market inefficiencies. Estimations with nonlinear regressors, partially nonparametric regressions and sign/size bias tests show evidence of nonlinear exposures.

The international evidence is not much different. Prasad and Rajan (1995) investigate the exposures of firms in several countries and report percentages of industry portfolios with significant exposure of 15%, 4% and 6% for the United States, Japan and the U.K., respectively. Results by Bodnar and Gentry (1993) are similar with 23%, 21% and 25% for the United States, Canada, and Japan, respectively. Dominguez and Tesar (2001) investigate firm-level exposures across eight industrialized and emerging market countries and find between 14% (Chile) and 31% (Japan) of the firms exposed to foreign exchange rate risk. Doidge, Griffin and Williamson (2001) conduct a comprehensive global study that confirms the evidence of previous investigations.

Our paper seeks to shed light on the exposure puzzle by focusing on the potential impact of an important economic event; namely, the introduction of the Euro in 1999. The study most relevant to our analysis is Bartov, Bodnar and Kaul (1996) in which they considered the similar, yet opposite phenomenon, of the switch in 1973 from fixed to floating exchange rates following the breakdown of the Bretton Woods system. They study two five-year periods of monthly returns around 1973 and show that stock return volatility of 109 U.S. multinationals increased significantly by 30 basis points (from 0.77% per month to 1.07% per month) compared to samples of control firms. They also document about a 10% increase in the market risks for those multinational firms while those of the control firms do not change or even decrease.

3 Research Design and Data

3.1 Research Design

The empirical analysis investigates the foreign exchange rate exposure of individual nonfinancial firms as well as portfolios of firms. We group firms according to whether they are located in the Euro countries ("Euro area"), in European countries that do not participate in the Euro ("Non-Euro Europe"), as well as firms outside of Europe ("Outside Europe"). The analysis examines weekly stock returns and exchange rate changes with data that spans the period January 1990 through August 2001, covering the period before and after the introduction of the common European currency Euro on January 1, 1999.

Foreign sales have been shown to be a determinant of foreign exchange rate exposures of nonfinancial firms (Jorion, 1990; Bodnar and Wong, 2003). Therefore, three types of geographic segment sales are considered for each firm: domestic sales, non-domestic or foreign sales in the Euro area, and total foreign sales. Sales in all of Europe are available for a larger number of firms and are thus considered as a proxy for Euro area sales as well. Our basic premise is that firms with a high fraction of foreign sales in the Euro area are expected to gain most from the reduction in foreign exchange rate risk through the introduction of the common European currency.

As a first approach, we follow Bartov, Bodnar and Kaul (1996) in calculating the variances of stock returns of individual firms and equally-weighted portfolios of firms for the periods before and after the introduction of the Euro. A significant reduction or a significantly lower increase in stock return variances would be in line with lower foreign exchange rate exposure of firms that are exposed to exchange rate risk of European currencies prior to the introduction of the Euro because they have important sales in the Euro area. While exchange rate exposures may result from competitive effects as well (Williamson, 2001), we propose that they will originate more directly from cash flows of foreign sales and assets. More foreign business activities thus suggest a stronger sensitivity of firm value (as the present value of domestic and foreign cash flows) to foreign exchange rate risk. As a result, a positive relationship between foreign exchange rate volatility and stock return volatility of multinational firms is expected.

In order to obtain an aggregate measure of the firm-specific tests of differences in variances before and after the Euro, the following chi-squared statistic is computed:

$$\chi^2(2N) = -2\sum_{i=1}^{N} \ln(p_i), \tag{1}$$

where the *p*-values p_i originate from *F*-tests of the change in stock return variance of firm *i* in the sample of *N* firms. As discussed in Bartov, Bodnar and Kaul (1996), this statistic is asymptotically distributed chi-squared with 2*N* degrees of freedom, assuming that the observations are independent of each other. The same underlying *F*-test is used for testing the change in return variances of regional portfolios. Tests are also conducted based on quartiles composed of firms with varying fractions of foreign Euro-area sales, foreign Europe sales, total foreign sales. We also perform tests across quartiles based on firm market capitalization. Wilcoxon rank-sum tests are performed across these quartiles to test differences in variances as well as differences in variance ratios.

The stock market betas of the sample firms are estimated using a simple market model in order to check whether their market risk has changed after the introduction of the Euro. A reduction in the market

beta could be an indication that foreign exchange rate risk is partially non-diversifiable. Lower foreign exchange rate risk should thus translate into lower market betas. This effect is expected to be bigger for firms with a large fraction of foreign sales in the Euro area than for firms with small sales in this region. The following regression model is estimated with OLS:

$$R_{ijt} = \alpha_{ij} + \beta_{ij} R_{Mjt} + \beta_{Euroij} R_{Mjt} D_{Eurot} + \varepsilon_{ijt}, \tag{2}$$

where R_{ijt} is the return of stock i in country j, R_{Mjt} is the return of the market portfolio in country j, and D_{Eurot} is a dummy variable that takes the value 1 after 1/1/1999 and 0 otherwise. Standard errors are corrected for autocorrelation and heteroscedasticity with the Newey-West procedure. Results are analyzed by region and for firms across different quartiles according to their percentage of foreign Euro-area sales, foreign Europe sales, total foreign sales and firm size. The standardized t-statistics of the coefficient estimates are aggregated into the following Z-statistic:

$$Z = \left(\frac{1}{\sqrt{N}} \right) \sum_{i=1}^{N} \frac{t_i}{\sqrt{k_i (k_i - 2)}}, \tag{3}$$

where t_i is the t-statistic of the coefficient of firm i, k_i are the degrees of freedom of the regression with firm i, and N is the sample size. As discussed in detail in Bartov, Bodnar and Kaul (1996), the sum of the standardized t-statistics is asymptotically normally-distributed with a variance of N, based on the assumption that the estimates are independent of each another. Thus, Z is distributed as a standard normal random variable. Moreover, Wilcoxon rank-sum tests of equal coefficients of firms in the different quartiles are performed. In addition to these tests, the percentages of significantly positive and negative coefficients are reported.

Using country-specific, trade-weighted exchange rate indices, foreign exchange rate exposures are estimated at the firm level while controlling for general market movements to test whether the incremental foreign exchange rate exposure has changed. This is the traditional approach of estimating foreign ex-

change rate exposures following Adler and Dumas (1984). The corresponding regression model is specified as:

$$R_{ijt} = \alpha_{ij} + \beta_{ij} R_{Mjt} + \beta_{Euroij} R_{Mjt} D_{Eurot} + \delta_{ij} R_{FXjt} + \delta_{Euroij} R_{FXjt} D_{Eurot} + \varepsilon_{ijt} , \quad (4)$$

where R_{ijt} is the return of firm i in country j, R_{Mjt} is the return of the market portfolio in country j, R_{FXjt} is the percentage change of a trade-weighted exchange rate index for country j, and D_{Eurot} is a dummy variable that takes the value 1 after January 1, 1999 and 0 before that date. As before, standard errors are corrected with the Newey-West procedure.

The Z-statistic is calculated for firm-level regressions to assess the overall importance of the level and change in market risk and foreign exchange rate risk exposures. Also, sign tests of equal coefficients of firms in the different quartiles are performed. Moreover, the fractions of firms with significant positive or negative exposure coefficients are reported in order to assess the economic significance and direction of the estimated effects.

The robustness of the results is investigated by estimating a pooled regression, which allows a joint test of the time series effect of the changing exchange rate regime as well as for cross-sectional differences in market betas and exchange rate exposures depending on the geographic pattern of foreign sales and the country of incorporation. This cross-sectional, time-series regression is implemented as a one-way fixed effects model. Thus, Eq. (4) is augmented by additional cross-sectional effects to estimate:

$$R_{qjt} = \alpha_{qj} + \sum_{q} \sum_{s} (\beta_{qs} R_{Mjt} + \beta_{Euroqs} R_{Mjt} D_{Eurot} + \delta_{qs} R_{FXjt} + \delta_{Euroqs} R_{FXjt} D_{Eurot}) D_{qj} D_{sj} + \varepsilon_{qjt} \quad (5)$$

where R_{qjt} is the return of the q^{th} quartile portfolio in country j, R_{Mjt} is the return of the market portfolio in country j, R_{FXjt} is the percentage change of a trade-weighted exchange rate index for country j, and D_{Eurot} is a dummy variable that takes the value 1 after January 1, 1999 and 0 before that date. D_{qj} are dummy variables that are 1 if the firm is in the q^{th} quartile (q = 1, 2, 3, 4) of alternatively the percentage of foreign Euro area sales, foreign Europe sales, total foreign sales and firm size, and 0 otherwise. Similarly, D_{sj} are

dummy variables with value 1 if the firm is located in the Euro area, Non-Euro Europe and Outside Europe, respectively, and 0 otherwise. *F*-tests are conducted across the coefficients of the different quartile portfolios separately for market betas and exchange rate betas.

3.2 Data Sources

Compared to most existing exposure studies, this paper investigates a much larger and broader set of firms. In particular, the sample comprises of 12,821 publicly traded nonfinancial firms in Europe, the United States of America, and Japan. All firms are classified into different industry sectors on the basis of the FTSE Global Classification, and firms in the financial service industries (banks, insurance companies, etc.) are excluded due to their different business objectives and complex financial risks. Data on geographic segment sales, as well as total assets and total sales for the period 1992-2001 are from the OSIRIS database (Bureau van Dijk Electronic Publishing, www.bvdep.com). The database is particularly suitable for this investigation as the breadth and depth of the available foreign segment data exceeds that of other databases such as Worldscope. In particular, OSIRIS contains geographic segment data for a larger number of firms in Europe (4,433) compared to Worldscope (3,106), and also the total number of covered firms in Europe is larger (6,202 vs. 5,351).[1] At the same time, there are many more segments available for firms in all regions. OSIRIS has on average 18.3 geographic segments of sales for firms in Europe versus 2.8 on Worldscope, 8.3 segments for firms in Japan versus 2.1 on Worldscope, and 5.1 for firms the United States versus 1.7 on Worldscope. The richer scope of geographic segment analysis for European firms is of particular importance for this study given the fact that the Euro likely has its greatest impact for them. Consequently, firms with important trade or investment in these countries are expected to be affected differently by the introduction of the Euro than other firms, and foreign sales in the Euro countries proxy for this Euro currency exposure.

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[1] We are grateful to Mark Wessels at Bureau van Dijk Publishing for providing us with the comparative analysis of Osiris and Worldscope.

Foreign sales are defined as all sales in geographic segments other than the domestic market. Euro area sales are defined as all sales in geographic segments of the countries participating in the Euro (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain). Europe sales are defined as all sales in the Euro area plus geographic segments of Denmark, Norway, Poland, Sweden, Switzerland, Turkey, UK and all geographic segments indicating Europe in general or any combination of European countries. If a geographic segment indicates sales in European and non-European countries, the sales of this segment are included only in the total foreign sales variable.

Percentages of foreign sales are calculated by dividing the foreign sales in a geographic area by the corresponding value of total sales for the firm and year. We average these percentages across all years for which we have available data for each firm. If the sum of all reported geographic segment sales exceeds the reported value of total sales, percentages of foreign sales are calculated by dividing the foreign sales in the area by the sum of all geographic segment data for each firm and year. Percentages that – as a result of data errors, sales discounts, or other data problems – exceed 100% or are negative are excluded. Subsequently, averages of these values are calculated for each firm based on all data available. If only data on domestic sales is available, percentages of foreign sales are calculated as the difference between total sales and domestic sales. For the percentage of total foreign sales (but not for foreign Euro area sales and foreign sales in Europe), firms without geographic segment data are assumed to be operating in the domestic market only, as they are typically required to report any segments that are material.

Table 1 provides descriptive statistics of the sample firms. The average firm in most European countries has high foreign sales in the Euro area, but there are also notable differences across European countries. Firms in Austria (38.5%), for example, have a high percentage of foreign Euro area sales, while these percentages are low in Finland (18.1%), Portugal (15.1%) and Spain (7.2%). There are also firms in Non-Euro Europe with a high fraction of foreign Euro area sales, such as in Switzerland (39.5%). Data on geographic segment sales in all of Europe are available for a larger number of companies – 2,495 compa-

nies versus only 607 companies with Euro-area sales data. Foreign sales in Europe are relatively low for firms in Japan (12.5%) and the United States (20.8%). At the same time, the differences across European countries in their foreign Europe sales are less dispersed with means in the range of 30% to 55%. Important exceptions include the UK (21.8%) and Luxembourg (60.9%).

The data on the percentage of total foreign sales has the most comprehensive coverage (12,821 companies) and also varies dramatically across firms in different countries. The average Japanese and U.S. firm has low foreign sales (2.3% and 5.6%, respectively). Within Europe, firms in Switzerland (61.1%), Ireland (58.9%) and Luxembourg (54.2%) have a high level of foreign business, while Turkey (2.7%), Greece (4.5%) and Poland (10.6%) have lower average percentages of foreign sales. Because total foreign sales has the greatest coverage, another interesting feature of the data emerges; namely, the skewed distribution of firms with foreign sales. For example, in the U.S. the mean total foreign sales percentage of 5.6% is attributed to the highest quartile of firms, as the first three quartiles of the 5,150 firms have no foreign sales. The skewed distribution of total foreign sales across firms is similar among the 3,162 Japanese firms.

Finally, firm size is measured by the log of market capitalization in Euro as of January 1, 1999, which is obtained from Datastream. The statistics show that the size of firms differs substantially across countries, even though the sample has a wide coverage of firms. The average firm in the sample is large (on average, around €2 billion or $2.3 billion) in Spain, Switzerland, the Netherlands and the United States, while small (on average, less than €250 million or $325 million) in Turkey, Norway, Poland and Austria.

Weekly returns for the stocks of all firms, market indices, and trade-weighted exchange rate indices (in local currency relative to the basket of foreign currencies) of the Bank of England are obtained from Datastream.[2]

4 Results

4.1 Stock Return Volatility

Descriptive statistics of returns and variances of trade-weighted exchange rate indices and stock market indices are presented in Table 2 for the full-period (1990-2001) and for the two relevant subperiods (1990-1998 and 1999-2001). As expected, the exchange rate indices of all Euro countries become less volatile through the Euro, and this is the case for countries in Non-Euro Europe and outside of Europe as well (Panel A). The most dramatic declines occur for the Finnish Markka, Italian Lira, Portuguese Escudo, which no longer exist, and the Swiss Franc, which still does. In contrast, stock market volatility increases for stock markets in many countries after the introduction of the Euro (Panel B). The largest increases occur in Finland (12.8% to 47.2%), and Greece (23.1% to 31.0%). Even the capitalization-weighted world market index volatility increases from 4.0% to 5.3%. At the same time, there are several countries where stock return variances are smaller after the Euro, such as Austria, Norway, Italy and Spain. These results are consistent with findings by Morana and Beltratti (2002) as well as Billio and Pelizzon (2002) that the introduction of the Euro has stabilized the Spanish and Italian stock markets, while not generally leading to lower volatility of stock markets in other countries. Note, that these market indices also include financial intermediaries and are value-weighted.

Table 3 presents the analysis of pre- and post-Euro stock return variances for the individual sample firms (Panel A) as well as for regional portfolios of the sample firms (Panel B). For individual nonfi-

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[2] The definition of the exchange rate variables corresponds to Jorion (1990), who uses "… the rate of change in a trade-weighted exchange rate, measured as the dollar price of the foreign currency. Thus, a positive value for R_{st}

nancial firms, stock return variances are significantly higher after the introduction of the Euro in most countries. The mean (median) stock across all firms has a variance of 52.0% (38.6%) in the pre-Euro period and 90.5% (57.3%) in the post-Euro period. Note that these are raw weekly return variances; that is, a 38.6% weekly variance corresponds to an annualized 44.8% standard deviation per year, which is reasonable given the breadth of the sample around the world. The associated chi-squared test easily rejects the null hypothesis that the variances in the two periods are equal.[3] Individual stock returns are significantly more volatile after the introduction of the Euro in Germany, Greece, and the U.S., where the median firm variance increases from 61.1% pre-Euro to 129.5% post-Euro. Because of the size of the U.S. sample, the increase in stock return variances for the sample of firms outside Europe is also much greater than that for Euro area and Non-Euro European firms.

Tests with equally-weighted portfolios of nonfinancial firms in Panel B show that stock returns are significantly more volatile after 1999 for firms in the Euro area, in Non-Euro Europe and outside of Europe.[4] The portfolio of Euro area stocks increases from 1.84% pre-Euro to 3.01% post-Euro (*F*-statistic of 1.63, *p*-value less than 0.001), but that of stocks outside Europe increases from 3.84% to 6.66% (*F*-statistic of 1.74, *p*-value less than 0.001). These results are important because, as portfolios, they account for the non-independence of the individual stock returns and yet confirm the results in Panel A. Overall,

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indicates a dollar depreciation" (page 335). Bartov, Bodnar and Kaul (1996), in contrast, use "…the foreign currency value of the U.S. dollar)" (page 111).

[3] The magnitude of the chi-squared statistics is comparable to those of Bartov, Bodnar and Kaul (1996) given our sample is 100 times larger than theirs. Indeed, they and we caution readers about interpreting these traditional statistics because of the sample size and because of the implicit assumption that the observations are independent of each other.

[4] Note that as shown in Panel A, the number of stocks in the sample is slightly larger in the Euro period, which should, *ceteris paribus*, lead to lower portfolio variances due to diversification effects. At the same time, correlations between stocks in different countries have become stronger over time, thus possibly reducing or counterbalancing this effect to some extent.

despite exchange rate stabilization due to the Euro, stock returns of most nonfinancial firms have evidently become more volatile rather than less.[5]

Firms might react differently to the reduction of foreign exchange rate risk through the introduction of the Euro depending on the extent and geographic pattern of their foreign sales. In particular, if lower exchange rate risk has a tendency to reduce stock return volatility, firms with important foreign sales in the Euro area are expected to have smaller increases in stock return volatility. Table 4 presents tests for differences in the changes in individual stock return variances around the introduction of the Euro by quartiles of Euro-area sales, Europe sales and total foreign sales. We report the means and medians but only of the first and fourth quartiles by each foreign sales category; Wilcoxon rank-sum tests of equal variances and post- versus pre-Euro variance ratios test are reported for each category and separately for Euro-area, non-Euro European and outside Europe stocks.

Firms show significantly different changes in stock return volatility depending on whether they have high and low foreign Euro area sales (Table 4, Panel A). As indicated by the ratios of the Euro variance to the pre-Euro variance, the stock return variance of firms in the Euro area with low foreign Euro-area sales increases more after the introduction of the Euro (1st quartile median variance ratio of 1.15) compared to firms with high foreign Euro area sales (4th quartile median variance ratio of 1.05), but the Wilcoxon test cannot reject that the variance ratios are equal (*p*–value of 0.135). Similar observations can be made for firms in Non-Euro Europe, where the median variance ratios are 1.23 and 0.97 for firms in the 1st and 4th quartile, respectively, but the Wilcoxon test rejects equality of variance ratios (*p*-value of 0.007). These results are consistent with the conjectures about the foreign exchange rate exposure of these

[5] There are several possible hypotheses unrelated to the Euro for the observed higher volatility in the U.S. after 1999. One important one that is investigated in Ofek and Richardson (2003) is the impact of the rise and fall of internet stock prices. Their Figure 1 and Table 1 relate the returns and trading activity in the internet sector to the non-internet sector of the S&P 500 and Nasdaq composite indexes. It could also be an extrapolation of the secular trend observed in individual stock return volatility, which primarily stems from its idiosyncratic component, as documented by Goyal and Santa-Clara (2003).

firms. Surprisingly, the effect seems reversed for firms outside of Europe. Part of the problem here is the limited coverage for firms outside Europe with data on Euro-area sales; for example, there is only one Japanese firm out of 3,162 for which we have data on total foreign sales and only 60 U.S. firms versus 5,150 with data on total foreign sales.

For firms in the Euro area with high foreign Europe sales (Panel B), variance increases are smaller (median variance ratio of 1.09 for firms in the 4th quartile versus 1.16 for 1st quartile firms). Moreover, the increase in stock return variances is significantly lower for 4th quartile firms in the Euro area compared to firms in the same quartile for non-Euro Europe (variance ratio of 1.26) and for outside Europe (variance ratio of 1.78). Only for the firms outside Europe does the Wilcoxon test reject the null hypothesis of equal variance ratios for the firms in the 1st and 4th quartiles of foreign Europe sales. Panel C shows that firms with high levels of total foreign sales, which represents our broadest sample of multinationals yet, have significantly lower stock return variances than firms with low levels of foreign sales. If multinationals are located in the Euro area, their variances increase significantly less after the introduction of the Euro compared to domestic firms in that area (median variance ratios of 1.11 versus 1.16 with *p*-value of 0.069), but this effect is reversed for firms outside of Europe. For non-Euro Europe, the median variance ratios are only 1.07 for the low foreign sales firms and 1.29 for high foreign sales firms and these are significantly different by the Wilcoxon test. The magnitude of the pre- and post-Euro variances for the sample outside Europe is now comprehensive, but it is heavily influenced by the high mean and median variances of the U.S. sample as we saw in Table 3.

Finally, Panel D shows that large firms inside and outside of Europe have significantly lower stock return variances compared to small firms. Moreover, large firms in the Euro area show lower increases in volatility after the introduction of the Euro compared to small firms relative to similar comparisons in non-Euro Europe and outside Europe. The inconsistency across firms by region is unexpected given the similarity of the distribution of market capitalizations across firms by country in Table 1. For

example, the differences in variance ratios between large and small firms outside Europe are likely influenced by the magnitude of the variances of the small firms. In the case of the smallest capitalization stocks outside Europe, both pre- and post-Euro variances are more than twice as large as those for small stocks within the Euro area and non-Euro Europe. As a result, we continue to control for differences in market capitalization in each of the remaining tests of the paper.

Thus, while stock return volatility of nonfinancial firms generally increased, the result that the increase is less for European firms with a high fraction of foreign sales in the Euro area (or foreign Europe sales or total foreign sales or firm size) is consistent with reduced foreign exchange rate exposures of these firms. This finding is in line with Bartov, Bodnar and Kaul (1996), who document a significantly higher increase in stock return volatility for U.S. multinationals as a result of the increase of foreign exchange rate risk after the breakdown of the Bretton Woods system. However, we do find that, for firms outside the Euro area, the increases in stock return volatility are actually greater for those with high fraction of foreign Euro-area sales, foreign Europe sales and total foreign sales. This is not necessarily consistent with Bartov, Bodnar and Kaul. One possible reason for the inconsistencies is that our focus on total stock market risk masks the differences of the potential impact of the Euro on the various components of risk. In the next section, we distinguish between the changes in systematic market-risk and foreign exchange rate risk components and the idiosyncratic risk.

4.2 Changes in Market Risk

Following Eq. (2), regressions of stock returns on local-market indices are performed in order to assess whether the introduction of the Euro is associated with changes in market risk of the sample firms. The detailed geographic segment sales data of the OSIRIS database is exploited here as well by comparing the effects for firms with high and low values of foreign Euro area sales, foreign sales in Europe, total foreign sales and market value, as well as by region. We report the median values of market betas (hereafter, β) as well as of the changes in the betas following the introduction of the Euro (hereafter, β_{Euro}), *p*-values

of two-sided sign tests (*Z*-statistic) that the means/medians equal zero, the fraction of statistically significant positive and negative values of β and β_{Euro}, respectively, and Wilcoxon rank-sum tests that the coefficients across two groups are equal.

Across all firms, the median β estimates are around 0.65 and almost 80% are statistically significant and positive. These estimates are very much in line with those reported in Bodnar and Wong (2003, Tables I and VI) and likely stem from the large number of smaller capitalization stocks in the sample and the use of a market-cap weighted local market index in the regressions.[6] Panel D illustrates this point by showing that the βs of lowest quartile of stocks according to market capitalization average βs around 0.39 while those of the highest quartile average 0.92, a statistically significant difference. While the differences between median βs across highest and lowest quartiles according to foreign Euro-area sales is not significant for the overall sample of firms (*p*-value of Wilcoxon test is 0.124), those same differences are significant in the Euro area and outside Europe. Measurably higher βs are obtained for those firms with higher versus lower foreign sales in Europe (Panel B) and higher versus lower total foreign sales (Panel C). These differences among quartiles of foreign sales are largest for firms in the Euro area and outside Europe and smallest for those firms within Europe but outside the Euro area. This is important as it impacts on the magnitude of the declines in βs observed after the introduction of the Euro.

The results indicate that market risk is significantly reduced for firms in and outside of Europe after 1999. Across all firms, the change in market betas (β_{Euro}) is significantly negative as measured by the *Z*-statistic and this result applies for all quartiles of firms by type of foreign sales or market capitalization and for all regions of the world. For example, the median β_{Euro} is -0.20 and typically about 30% of the firms have significantly negative estimates versus 6% with significantly positive estimates. The largest capitalization firms experience a much larger decline than smaller capitalization firms, no doubt, partly

because their βs are higher in the first place. Panel D shows that the highest quartile firms by size have β_{Euro} around -0.36 (45% significantly negative) while the smallest quartile have a median β_{Euro} of -0.05 (12% significantly negative); this difference is significant by the Wilcoxon test (*p*-value less than 0.001).

Important differences in the decline in market betas following the Euro arise for firms depending on the extent of foreign sales activity. The median coefficients of the change in market betas after the Euro are –0.193 and –0.204 for the 1st and 4th quartiles based on foreign Euro area sales, respectively (Panel A) and are –0.190 and –0.204, for quartiles based on foreign sales in Europe (Panel B). Neither of these differences is significant by the Wilcoxon rank-sum tests (*p*-values of 0.37 and 0.33, respectively). At the same time, the respective declines in market betas are –0.176 and –0.223 for the 1st and 4th quartiles based on total foreign sales (Panel C), which does represent a significant difference. Part of the explanation for this inconsistency may stem from the much larger sample of firms for which we have total foreign sales data, but the weak differences across quartiles of foreign sales in the first two panels may mask important patterns across regions. For example, the firms with the highest quartile of foreign sales in Europe experience much larger declines in market betas than those in the lowest quartile for those firms in the Euro area and outside Europe, but not for those outside the Euro area in Europe. A similar pattern obtains for total foreign sales (Panel C).

Overall, there is strong evidence suggesting that the reduction in foreign exchange rate risk brought about by the introduction of the Euro is accompanied by significant decreases in market risk for firms. The decrease in market risk is typically greater for larger capitalization firms and those with a higher percentage of foreign sales, especially to the Euro area. The results can be interpreted as support for the conjecture that foreign exchange rate risk is at least in part non-diversifiable. They are consistent with those of Bartov, Bodnar and Kaul (1996) who document significant increases in market risk of U.S. multi-

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[6] Not tabulated results show that the average, value-weighted market betas are close to one, particularly when including firms of the financial sector. Moreover, as expected, the betas of the majority of firms is indeed positive.

nationals after the breakdown of the Bretton Woods system when foreign exchange rate risk increased. Lower foreign exchange rate exposures in the form of reduced market betas are an important finding as they imply the potential to carry higher business risk or to sustain more financial leverage. Moreover, reductions in market betas entail reduced cost of capital with concomitant benefits for corporate investment and firm valuations. This result is in line with findings in a study of European firms by Bris, Koskinen and Nilsson (2002) that the introduction of the Euro is associated with significant increases in the Tobin's *q* of firms in general and large firms in particular.

4.3 Change in Foreign Exchange Rate Exposure

Foreign exchange rate exposures are traditionally estimated by regressing foreign exchange rate variables on stock returns while controlling for general market movements (Bodnar and Wong, 2003; He and Ng, 1998; Prasad and Rajan, 1995; Bartov and Bodnar, 1994). The incremental, or "residual" effect measured by the exchange rate coefficient is then interpreted as exchange rate exposure in the spirit of Adler and Dumas (1984). In Table 6, we investigate these incremental exchange rate effects around the introduction of the Euro by estimating Eq. (4) in which the overall exposure is given by δ and the change in the exposure after 1999, by δ_{Euro}. We report similar summary statistics as in Table 5 but for all four coefficients (β, β_{Euro}, δ, δ_{Euro}), including medians, associated Z-statistics, percentages of significant positive and negative coefficients and Wilcoxon rank-sum tests of equality across subgroups.

Overall, the fraction of firms with significant foreign exchange rate exposures overall and with significant changes in those exposures around the Euro launch is small and substantially lower than for changes in market risk. On average, across all quartiles of foreign sales and market capitalization and across all regions, the firm-level exposures are negative. For example, the median δ is -0.054 for firms with the highest quartile of foreign Euro-area sales (significant *Z*-statistic with *p*-value of 0.01) and, for those in the lowest quartile, it is -0.042 (*p*-value less than 0.001). In this particular case (Panel A), the Wilcoxon test indicates the difference is small and insignificant (*p*-value of 0.26). The fraction of signifi-

cant negative values is not great, however at 2.3% and 4.2%, respectively, which is actually smaller than the number of significant positive values (6.1% and 5.9%, respectively). The finding of negative exposures appears counter to economic intuition as it implies that firms experience declines in firm value (relative to the market) when the local currency appreciates.[7] It is, however, consistent with results reported in previous research, e.g. Jorion (1990) shows that the foreign exchange rate exposures of his sample of 287 U.S. multinational firms are negative but they diminish to zero with a greater fraction of foreign sales. In particular, Jorion (using the same exchange rate definition) reports average exposures of -0.234 (1971-75), -0.079 (1976-80) and -0.078 (1981-87). Similarly, Bodnar and Wong (2003) (using the inverse exchange rate index) report positive mean and median exposure for all estimation horizons with the value-weighted market index as control variable, which matches our findings.

The other important finding is that the average change in foreign exchange exposure following the introduction of the Euro is positive. For example, among firms in the highest quartile of foreign Euro-area sales, the increase in exposure (δ_{Euro}) is 0.157 (*Z*-statistic has a *p*-value of 0.001) and for those in the lowest quartile, it is 0.068 (*p*-value of less than 0.001). The fraction of significantly positive values of δ_{Euro} (around 4%, on average) far outnumbers those of significantly negative values (around 0.1%), which suggests that this finding of a positive shift in foreign exchange exposures is pervasive across the sample. Along the same lines, the change of the exchange rate exposure in the study by Bartov, Bodnar and Kaul (1996) also has the opposite sign as the exposure to exchange rate risk before the transition to flexible exchange rates.

Results for quartiles on the basis of foreign Euro area sales suggest that the Euro is associated with a significant change in the incremental foreign exchange rate exposure (from negative to positive) for

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[7] Also, Clarida (1997) shows that the rise of the U.S. dollar in the early 1980s reduced U.S. manufacturing firms' profits by 25 % while the subsequent fall boosted profits by 30%. Hung (1992) also reports $23 billion per year in cumulative total losses to U.S. manufacturing firms during the upward swing in the U.S. dollar in the 1980s. See also Figure 4 in Bodnar and Wong (2003).

firms with high foreign Euro area sales (4th quartile) (Panel A). The difference between highest and lowest quartile is significant by the Wilcoxon rank-sum test (*p*-value of 0.045). The effect seems to be concentrated in non-Euro Europe and outside Europe, although the differences within those regions are not significant by themselves. A similar pattern is observed for quartiles by foreign Europe sales (Panel B) and total foreign sales (Panel C). That is, those firms with the lowest quartiles of foreign sales have more negative net foreign exchange exposures than those with highest quartiles of foreign sales, but those with the highest foreign sales experience a larger positive change in exposure with the launch of the Euro. In each of Panels B and C, the pattern is also concentrated in firms from non-Euro Europe and outside Europe. Finally, Panel D examines the differences by quartiles of market capitalization and finds that the exposures before the Euro are significantly more negative for smaller capitalization firms than larger capitalization firms, but that the positive shift in exposures following the Euro is significant but not distinguishable by quartile. For example, across all firm, smallest quartile firms have a median δ of -0.051 while largest quartile firms have a median δ of -0.031, both significantly different from zero by *Z*-statistic, and from each other by the Wilcoxon rank-sum tests. At the same time, both incremental exposures (δ_{Euro}) following the Euro equal 0.058, again significantly different from zero by *Z*-statistics but not from each other by the Wilcoxon tests.

It is important to note that almost all of the inferences about market risk exposures and their changes around the introduction of the Euro in Table 6 are consistent with those in Table 5 and the discussion in the previous section. Overall, we find that the market betas are higher for larger capitalization firms and those with a higher fraction of foreign sales and it is those firms that experience the most significant decline in betas following the Euro. The only notable inconsistencies between the two tables stem from the differences across high and low quartiles of firms' median β and β_{Euro} by their foreign sales in Europe, which are no longer significantly different by the Wilcoxon test. This inconsistency for the full sample

results in spite of the fact that the differences are still significant and large among the two key subsets of firms in the Euro area and outside Europe.

Overall, the results suggest that the stabilization of foreign exchange rates, as entailed by the introduction of the Euro, leads to lower risk of nonfinancial firms. In particular, market risk for firms within and outside of Europe is significantly reduced as foreign exchange rate risk decreases. Moreover, the Euro has a positive effect on incremental foreign exchange rate exposures. These results are in line with those reported by Bartov, Bodnar and Kaul (1996) who, using the trade weighted value of the U.S. dollar (in foreign currency per U.S. dollar, i.e. the inverse definition of our exchange rate variable), document a significant positive effect of the increase in exchange rate volatility after the breakdown of the Bretton Woods system (in contrast to the decrease of exchange rate volatility in our case) on the foreign exchange rate exposure of U.S. multinationals.

It is important to note that the results are strongest for changes in market risk, while the additional, incremental changes of the foreign exchange rate betas are substantially less significant. This finding suggests a conceptual problem of the classical approach of estimating exchange rate exposures by regressing a market index and exchange rate variables on stock returns. Traditionally, only the coefficient of the exchange rate factor is interpreted as exchange rate exposure, while that for the market factor (and that of other regressors) is interpreted as a control variable. Nevertheless, the results in this paper suggest that an important component of the foreign exchange rate exposure is inherent in the market index. Consequently, the failure to detect significant exchange rate exposures empirically may not be the result of a lack of foreign exchange rate exposure of nonfinancial corporations. Rather, it may be that the result of measuring the foreign exchange rate exposure as the coefficient of the exchange rate variable, which only captures the incremental or "residual" effect in the presence of the market index (Bartram, 2003). Evidence that exposure coefficients are sensitive to the choice of control variables (value-weighted or equally-weighted market index) support this idea (Bodnar and Wong, 2003).

4.4 Robustness Tests

We conduct a number of robust tests related to methodology, data and analysis. First, our insights up to now into the interaction of firm characteristics, exposures and changes in exposures are derived from a series of individual tests by market capitalization and foreign sales quartiles, other firm characteristics and home country. In order to check the robustness of these results, we estimate a pooled time-series cross-sectional regression model (Eq. (5)) of stock returns on market indices and exchange rates in which we distinguish firms across quartiles and location using various dummy variables.[8] The regression is performed separately for quartiles of firms by Euro sales, Europe sales, total foreign sales and market capitalization. The importance of these tests is that they acknowledge and incorporate potential cross-sectional dependence in the residuals of the separate regression models and offer more power to our inferences.

The results corroborate the finding that these determinants matter for the level and the change in both the market risk exposures and foreign exchange rate exposures. In particular, regressions that distinguish between high and low foreign Euro area sales in addition to region and time period confirm the significant changes of market betas, indicating that they decrease with the introduction of the Euro especially for 4th quartile firms in the Euro area (-0.217) and in Non-Euro Europe (-0.298). While the coefficients of the change in market betas are negative for 1st quartile firms as well (and significant for firms in the Euro area as well as outside of Europe), the decrease is significantly larger for firms with high foreign Euro area sales. The changes in foreign exchange rate exposures are mostly positive and larger for firms with a higher fraction of Euro sales, but they are insignificantly different from each other and from zero.

The results are quite robust to using the percentage of foreign sales in Europe and total foreign sales as alternative exposure proxies. Regressions based on total foreign sales, for example, also show decreases in market betas for multinational firms in the Euro area (-0.205) and outside of Europe (-0.397)

[8] Results of these estimations are available from the authors upon request.

that are much larger than for domestic firms in the Euro area (-0.022) and outside Europe (-0.124). For quartiles based on market capitalization, large firms show significant decreases in market betas, while the change in market betas is significantly positive for small firms. Unlike our earlier tests in Table 6, none of these pooled cross-sectional time-series regression reveals significantly different changes in foreign exchange exposures after the Euro. Indeed, *F*-tests confirm the earlier finding that the *level* of the market risk and foreign exchange rate exposures are significantly different across quartiles, but the *changes* in those levels after the Euro are only significantly different for market risk exposures, not foreign exchange exposures. Overall, the results offer additional evidence in support of the conjecture that the level and change in market exposure are systematically related to foreign sales (in the Euro countries) and firm size, but the level and change in foreign exchange exposures is not so clearly related.

Second, the investigation covers a period that includes the breaking of the Tech-Media-Telecom bubble in early 2000. To investigate the effects of this factor on the results, we re-estimate Tables 3-6 for the sample after excluding 3,357 firms in the relevant industries. The results of these robustness checks are largely similar to the full sample, leaving our conclusions regarding the main arguments of the paper unchanged.[9]

Third, it may be argued that market participants anticipated the introduction of the Euro, so that its effect should be reflected in stock prices already before 1999. We investigate this conjecture by excluding the year 1998 as a transition period, by using January 1, 1998 as alternative date of the introduction of the Euro, or by limiting the sample period to the years 1993-1996 (pre-Euro) and 1999-2001 (post-Euro). The results are robust to these alternative specifications, which suggests that the economic effects we observed are not simply transitional in nature.[10]

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[9] These results are available from the authors upon request.

[10] These results are available from the authors upon request.

Fourth, increasing globalization and integration of markets could result in assets being mainly priced on an international scale, thus rendering the use of local market indices less relevant. As a result, we replicate all of our tests in Tables 5 and 6 (as well as the pooled time-series cross-section estimation) using a global market index (the Datastream World Market Index in local currency) instead of the respective domestic market indexes by country. Again, the results and our primary inferences do not change.[11]

Fifth, the results in this paper are based on unadjusted values for the percentages of foreign sales and firm size. To illustrate, a French firm with 20% of foreign sales is assumed to be more exposed to foreign exchange rate risk than a U.S. firm with 10% sales abroad, even though the French firm has foreign sales below the mean/median French firm, while the U.S. firm has more foreign sales than the average company in the United States. However, while the use of unadjusted values appears more appropriate, using country- and industry-adjusted firm characteristics has little effect on the results. Finally, we are concerned with our ability to compare the results to prior studies, such as Jorion (1990) and Bodnar and Wong (2003). These studies employ a two-step estimation procedure in which they compute market risk and foreign exchange risk exposures using a time series model and then regress the estimated coefficients on firm attributes like foreign sales and market capitalization. The advantage of their approach is that they do not rely on quartiles as the key cutoff criteria, but their two-step procedure is likely to be less efficient than a pooled system. We replicate their approach for market risk exposures (β, β_{Euro}) and foreign exchange rate exposures (δ, δ_{Euro}) before and after the Euro, and find that again our basic inferences about differences in changes in market risk exposures (β_{Euro}) across firms by Euro area sales, Europe sales, total foreign sales and size are maintained. Once again, however, the inferences about changes in foreign exchange expo-

[11] These results are available in a separate table from the authors upon request. We are grateful to Vihang Errunza for this suggestion.

sures (δ_{Euro}) are more fragile: the positive and significant change and differences by foreign sales and size are retained for foreign Europe sales and total foreign sales, but not for foreign Euro area sales.[12]

5 Discussion of Results and Alternative Interpretations

Several caveats are needed to put the empirical results into perspective. Most importantly, financial markets are characterized by increased market liberalization, integration, and higher volume of cross-border transactions both with regard to real goods and investment flows. These developments may indeed represent an explanation for the documented overall increases in stock return volatility during our period of analysis. Higher stock return volatility may arise on a transitory basis as a consequence of the Euro for institutional reasons. It has been argued, for example, that a disadvantage of the fixing of exchange rates between the Euro countries is that it forces temporary economic adjustment processes to go through the real or labor sectors of the economy as firms rethink operational decisions such as overseas plant locations (Temperton, Chapter 1, 1999). Higher stock return volatility may also arise on a longer term basis with growing market integration over time. The survey by Karolyi and Stulz (2003) points to a number of studies that empirically associate increased cross-border capital flows with higher international stock return volatilities and correlations. This observation is important because it renders the result of significantly lower increases in stock return volatility of multinationals and significant decreases in their market betas even stronger. This is because multinationals should not only benefit more from the reduction in foreign exchange rate risk through the Euro, but should also be affected most by capital market integration leading to higher stock return volatility due to lower diversification benefits. Thus, we would argue that the documented results occur despite and not because of increased market integration.

Multinationals tend to be large firms that constitute an important fraction of the market portfolio. As a result, changes in the volatility of stock returns of multinationals could impact on the correlations

[12] These results are available from the authors upon request.

between these firms and the respective market portfolio leading to corresponding changes in the systematic risk. Bartov, Bodnar and Kaul (1996) document that higher foreign exchange rate risk after Bretton Woods is associated with higher stock return volatility of U.S. multinationals and significant increases in their market betas. The results in this paper indicate increases in stock return volatility for most sample firms as well, but the increase in volatility for multinationals and large firms is significantly *lower* than for other firms. Moreover, market betas as a measure of systematic risk are significantly reduced despite the increase in stock return volatility that might have been believed to lead to increases in correlations between the market portfolio and stock returns and thus higher betas.

Derivatives markets continue to grow rapidly, both with regards to breadth and depth, which greatly increases the availability of hedging instruments to nonfinancial firms. Moreover, it could be argued that increased globalization of businesses may not lead to larger exposures due to more foreign operations, but that firms, especially multinationals, may have increasingly the opportunity to establish production facilities abroad (as opposed to exporting) and to use real options as hedging instruments. Thus, changes in foreign exchange rate exposures could be a function of the changing degree of hedging at the firm level. There is little information available about changes in actual hedging practices over time (exceptions for the United States include Bodnar, Hayt and Marston, 1996, 1998, and Bodnar, Hayt, Marston, and Smithson, 1995), and, to our knowledge, there is no information about whether corporate hedging behavior has significantly changed after the introduction of the Euro.

Finally, market betas can change not only due to changes in the underlying asset risk (or asset betas) but also because of changes in financial leverage, since the market beta (β) of a firm is its asset beta (β_a) adjusted for the ratio of the market value of the assets (V) relative to the value of the firm (E):

$$\beta = \beta_a \frac{V}{E}. \tag{6}$$

Thus, the documented decreases in market risk could in principle be the result of lower financial leverage and not of lower asset risk entailed by reductions in exchange rate volatility. This issue is analyzed by studying the leverage and changes in leverage of the sample firms. Leverage is calculated for each firm as the average ratio of firm value (market value of equity plus book value of debt) to the market value of equity. Data for 1993 to 2001 on the book value of debt are obtained for our sample firms from OSIRIS, while market capitalization data are from Datastream. Table 7 presents means and medians of leverage before and after the introduction of the Euro as well as two-sample *t*-tests and two-sample median tests for differences across time. Overall, we find that leverage increases from a median of 1.72 to 1.79, which a statistically significant difference, but is economically small. Within the Euro area, the leverage actually decreases (1.98 to 1.70, by medians), while outside Europe, leverage increases (1.74 to 1.86, by medians). Interestingly, leverage decreases significantly in several countries (Finland, France, Greece, Italy, Sweden, Switzerland, UK, Turkey), although there are also countries where leverage significantly increases (Austria, Belgium, Denmark, Japan, Netherlands, United States). In most other countries, there is not a significant change in leverage of the sample firms. Basically, Table 7 does not give us a clear pattern of results that we can associate with changes in market risk exposures in previous tables.

Since market risk is a relative measure, it has also to be tested whether the change in leverage is significantly different for multinational versus domestic firms, as leverage would have to decrease significantly more for multinational firms in order to explain the stronger reduction in market risk of these firms. Table 8 provides additional tests of leverage changes by firm quartiles of foreign Euro-area sales, Europe sales, total foreign sales and market capitalization. When looking at results of Wilcoxon rank sum tests for differences across quartiles by any category of foreign sales, it appears that financial leverage increases significantly less for multinationals compared to domestic firms only in the case of firms in Non-Euro Europe. Leverage of multinational firms actually increases significantly more in the Euro area and outside of Europe. As a consequence, there is no strong evidence to support the alternative conjecture that the

documented decreases in market exposures are simply the reflection of reductions in financial leverage. Results by Bartov, Bodnar and Kaul (1996) for their sample of U.S. firms also support this view.

6 Conclusion

While financial theory predicts that foreign exchange rate changes affect the value of nonfinancial firms in general and those with foreign business operations or foreign competition in particular, the empirical evidence of foreign exchange rate exposures documented by a sizable number of empirical studies has been surprisingly weak. This paper investigates the effect of the introduction of the Euro as a common currency on 12,821 corporations in 21 countries around the world including the United States and Japan. It evaluates the hypothesis that a common currency leads to lower foreign exchange rate risk and, thus, lower foreign exchange rate exposures of nonfinancial firms.

We first confirm that the Euro does, in fact, lead to a substantial reduction in the volatility of trade-weighted exchange rates of European countries. We also show that, while stock return variances of nonfinancial firms increase during the sample period, the increase is significantly lower for firms with a higher fraction of foreign sales in the Euro area, in Europe or total foreign sales in general. The introduction of the Euro also leads to lower market risk exposures for firms in and outside of Europe. This finding suggests that foreign exchange rate risk is in part a source of non-diversifiable risk. The reduction in market risk is significantly larger for firms with high foreign sales in Europe, high total foreign sales and high market capitalization. In addition to its impact on market betas, the Euro has a positive effect on foreign exchange rate exposures, particularly for multinationals. This evidence on foreign exchange exposures is weaker and is somewhat sensitive to different methods of analysis, but the general patterns are consistent with the overall hypothesis. That is, firms should benefit from lower resources committed to risk management, increased potential to carry business risk or debt, reduced cost of capital and should experience higher firm valuations. We know that changes in market risk could, in principle, also result from changes in financial leverage, but this alternative explanation is not supported by the empirical evidence.

While ours is the most comprehensive firm-level analysis of foreign exchange exposures to date and capitalizes on an interesting and important experiment in the introduction of the Euro, we have to acknowledge several key limitations. Most important among these is the short time-horizon over which we run the experiment. Our data runs just under three years following the January 1, 1999 launch of the Euro. One expects a transition period to influence our results either before or after the event, but its duration and magnitude is not clear. Bodnar and Wong (2003) demonstrate how fragile inferences can be to using stock-return regression models with different specifications for exchange rate and market risks and when applied to different return horizons (from 1 month to 5 years); our short period of analysis post-Euro is likely to exacerbate such problems.

Another concern is the appropriateness of our benchmarking of affected firms. Our sample of firms is broad, but it only includes the U.S. and Japan outside Europe. It could be that our results are sensitive to the exclusion of Asian developed market firms and all emerging market firms in Europe, Asia, Africa and Latin America, for which Doidge, Griffin and Williamson (2002) have shown important foreign exchange exposure effects. Finally, though our experiment controls for firm-level attributes such as foreign sales, market capitalization and financial leverage, it is quite likely that macroeconomic and capital market effects play an important role in changes in stock return volatility as well as market and foreign exchange rate exposures. Our event-study approach limits our ability to offer any insights in this study, but it is important to recognize the potential contaminating influence of such country-level and global forces at work.

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Table 1: Descriptive Statistics of Sample Firms

The table reports statistics on the percentage of foreign sales in the Euro area, foreign sales in Europe, and total foreign sales as well as market capitalization by country across sample firms. *N* refers to the number of firms, *Q*1 to the 25% quartile, *Q2* to the 50% quantile or median, and *Q*3 to the 75% quartile.

	Foreign Euro Area Sales					Foreign Europe Sales					Total Foreign Sales					Market Capitalization (€ mills.)				
Country	N	Mean	Q1	Q2	Q3	N	Mean	Q1	Q2	Q3	N	Mean	Q1	Q2	Q3	N	Mean	Q1	Q2	Q3
Austria	14	38.5	17.9	41.3	57.9	35	54.4	37.8	57.9	70.9	75	49.0	4.9	50.3	87.8	68	271	22	92	268
Belgium	19	32.8	13.9	24.4	53.9	35	51.2	31.4	54.0	67.4	105	26.2	0.0	0.0	48.6	84	1170	47	133	725
Denmark	9	34.3	22.2	31.4	48.9	39	53.7	39.1	55.7	71.2	127	40.9	0.0	33.7	80.7	119	441	16	64	253
Finland	11	18.1	3.3	13.9	24.6	62	41.8	24.7	38.6	62.4	87	45.2	3.7	43.3	81.3	73	1268	49	233	569
France	62	19.5	9.4	17.4	25.7	222	31.3	18.3	30.8	40.8	559	31.6	0.0	26.7	55.7	486	1342	27	86	386
Germany	42	24.2	8.0	16.1	39.1	294	31.7	17.3	29.8	41.5	711	25.9	0.0	14.0	49.0	465	1339	36	113	408
Greece	0					0					118	4.5	0.0	0.0	0.0	82	447	35	81	294
Ireland	6	35.3	5.3	14.6	74.5	48	56.1	38.1	49.9	77.1	61	58.9	22.7	66.3	97.4	51	471	17	92	427
Italy	12	24.3	11.3	24.1	36.4	47	30.9	18.4	31.4	42.9	124	25.5	0.0	0.0	57.1	103	1788	88	282	1019
Japan	1	6.6	6.6	6.6	6.6	67	12.5	6.4	11.0	14.9	3162	2.3	0.0	0.0	0.0	2834	654	31	75	226
Luxembourg	1	95.6	95.6	95.6	95.6	5	60.9	30.8	75.5	83.8	11	54.2	0.0	96.2	100.0	11	868	17	459	1798
Netherlands	51	30.9	15.6	27.9	40.7	138	42.6	26.5	39.5	56.6	191	49.4	9.1	51.9	85.0	168	2328	62	193	968
Norway	16	15.4	4.1	17.1	24.5	54	47.4	30.1	43.9	61.5	140	31.0	0.0	0.0	73.2	134	208	26	63	174
Poland	4	17.9	8.6	15.2	27.2	6	28.3	17.6	21.5	35.0	41	10.6	0.0	0.0	16.0	34	238	12	34	62
Portugal	2	15.1	2.5	15.1	27.7	4	27.0	5.7	17.7	48.4	34	16.5	0.0	1.1	16.9	33	1157	67	142	877
Spain	1	7.2	7.2	7.2	7.2	9	29.0	7.2	29.6	42.1	73	14.4	0.0	0.0	19.5	65	2515	202	482	1742
Sweden	58	22.0	8.5	20.4	31.2	123	45.7	24.9	44.6	62.7	233	36.1	0.0	17.0	79.1	207	654	22	75	246
Switzerland	44	39.5	26.9	39.9	53.2	111	53.2	41.0	52.3	69.2	152	61.1	23.1	80.4	98.3	130	2391	66	186	530
Turkey	0					0					148	2.7	0.0	0.0	0.0	146	106	11	26	72
UK	194	17.1	4.8	13.9	22.9	883	21.8	6.8	16.4	29.7	1519	28.6	0.0	15.1	52.2	1378	903	15	51	240
US	60	14.8	5.0	11.2	16.7	313	20.8	10.5	17.6	25.9	5150	5.6	0.0	0.0	0.0	4152	1918	26	102	506
All firms	607	22.5	7.6	17.6	32.5	2495	30.5	12.1	25.4	43.5	12821	13.5	0.0	0.0	9.2	10823	1288	27	87	363

Table 2: Descriptive Statistics of Exchange Rates and Stock Market Indices

Panel A reports descriptive statistics for returns on exchange rates indices (in local currency relative to the basket of foreign currencies). Weekly average returns and variances of an effective exchange rate index are calculated for each country. Panel B reports average weekly returns and return variances of stock market indices. The full period ranges from January 1990 to August 2001 and is split into the pre-Euro period (1/1990-12/1998) and the Euro period (1/1999-8/2001). The stock market indices of Luxembourg and Poland start in 1/1992 and 3/1994, respectively.

Panel A: Exchange Rate Indices

	1990 - 2001		1990 - 1998		1999 - 2001	
	Mean	Variance	Mean	Variance	Mean	Variance
Austrian Schilling	-0.0005	0.0737	-0.0068	0.0823	0.0205	0.0445
Belgium Franc	-0.0011	0.1506	-0.0100	0.1662	0.0291	0.0976
British Pound	-0.0152	0.9857	-0.0116	1.0248	-0.0273	0.8598
Danish Krone	-0.0072	0.1540	-0.0186	0.1551	0.0315	0.1497
Dutch Guilder	0.0027	0.1433	-0.0064	0.1475	0.0336	0.1286
Finnish Markka	0.0383	0.7597	0.0388	0.9211	0.0365	0.2166
French Franc	-0.0052	0.1544	-0.0167	0.1639	0.0338	0.1214
German Mark	0.0019	0.2487	-0.0097	0.2685	0.0409	0.1814
Greek Drachma	0.1006	0.4204	0.1140	0.4824	0.0553	0.2102
Irish Punt	0.0191	0.4581	0.0082	0.4713	0.0558	0.4147
Italian Lira	0.0509	0.7515	0.0562	0.9413	0.0328	0.1116
Japanese Yen	-0.0482	2.5215	-0.0493	2.5771	-0.0447	2.3508
Norwegian Krone	0.0081	0.3988	0.0180	0.4344	-0.0254	0.2792
Portuguese Escudo	0.0194	0.1838	0.0180	0.2165	0.0244	0.0741
Spanish Peseta	0.0448	0.3805	0.0500	0.4657	0.0275	0.0936
Swedish Krona	0.0482	0.9955	0.0495	1.0749	0.0438	0.7332
Swiss Franc	-0.0236	0.5155	-0.0302	0.5933	-0.0013	0.2543
US Dollar	-0.0216	0.9206	-0.0053	0.9745	-0.0765	0.7400

Panel B: Stock Market Indices

	1990 - 2001		1990 - 1998		1999 - 2001	
	Mean	Variance	Mean	Variance	Mean	Variance
Austria	0.0518	6.2708	0.0495	7.0042	0.0597	3.8235
Belgium	0.1735	4.0678	0.2539	3.7495	-0.0983	5.0823
Denmark	0.2141	4.9297	0.2062	4.6538	0.2405	5.9021
Europe	0.1852	4.6343	0.2632	4.4245	-0.0784	5.2903
Finland	0.3169	20.6087	0.3684	12.8288	0.1428	47.1591
France	0.2277	6.5180	0.2277	6.1083	0.2278	7.9575
Germany	0.1717	6.0370	0.2136	5.4722	0.0298	7.9738
Greece	0.4033	24.9489	0.5338	23.1373	-0.0369	31.0205
Ireland	0.2738	6.2174	0.3181	6.3496	0.1240	5.7837
Italy	0.1641	10.6101	0.1965	11.4079	0.0547	7.9601
Japan	-0.1087	9.7708	-0.1643	9.1279	0.0794	11.9803
Luxembourg	0.3006	5.3159	0.3999	2.8977	0.0405	11.6210
Netherlands	0.2795	4.6755	0.3334	4.5780	0.0973	4.9971
Norway	0.1844	9.6305	0.1886	10.7218	0.1702	5.9914
Poland	-0.0800	31.0928	-0.1124	39.0447	-0.0215	16.9072
Portugal	0.1303	5.4004	0.2204	5.6641	-0.1732	4.4269
Spain	0.2394	8.1144	0.3251	8.5621	-0.0503	6.5420
Sweden	0.2568	11.3850	0.2882	10.4716	0.1504	14.5571
Switzerland	0.2559	5.3332	0.3283	5.6770	0.0109	4.1252
Turkey	1.1419	60.0768	1.1840	57.3297	0.9994	69.8219
U.K.	0.2231	4.2129	0.2758	3.9801	0.0448	4.9933
United States	0.2592	4.9716	0.3417	4.0403	-0.0194	8.0715
World	0.1326	4.3254	0.1751	4.0245	-0.0112	5.3522

Table 3: Analysis of Stock Return Variances

Panel A reports mean stock return variances across firms by country (region) in the pre-Euro and post-Euro period. Variances above the 95th percentile, below the 5th percentile and above/below 5 standard deviations of the median variance are excluded from the analysis. *N* refers to the number of firms. The test for change in variance is based on the null hypothesis that the variance of an individual firm does not change significantly. The chi-squared test statistic is calculated as $\chi^2(2N) = -2\sum_{i=1}^{N}\ln(p_i)$ where *N* is the number of firms, and p_i is the 2-sided probability value of the *F*-statistic of a test of change in variances for firm *i*. The reported probabilities are the significance values for the chi-squared test. Panel B reports portfolio variances of equally weighted portfolios by region. The test for change in portfolio variance is based on the null hypothesis that the variance of a portfolio does not change significantly. The *F*-statistic is the ratio of the larger variance to the smaller variance. The reported *p*-values are the corresponding 2-sided significance levels of the *F*-test.

Panel A: Individual Firms

	Pre-Euro Variances			Post-Euro Variances			Test for Change	
Country	N	Mean	Median	N	Mean	Median	χ^2	p-val
Austria	62	28.1	19.7	62	53.7	29.7	347	0.000
Belgium	70	37.1	18.1	94	43.5	28.1	723	0.000
Denmark	103	27.7	18.8	107	39.6	24.6	885	0.000
Finland	71	35.9	30.8	84	56.6	33.0	486	0.000
France	472	36.5	27.0	509	64.0	35.5	4,187	0.000
Germany	400	32.7	21.3	618	96.5	56.1	4,208	0.000
Greece	82	54.4	52.4	118	119.0	116.8	1,636	0.000
Ireland	45	41.9	22.1	53	73.7	42.2	597	0.000
Italy	103	31.6	26.4	114	43.5	25.4	629	0.000
Japan	2,726	41.6	37.1	3,034	59.2	45.8	26,654	0.000
Luxembourg	8	23.2	25.7	7	34.9	23.9	8	0.477
Netherlands	150	38.1	20.4	170	52.0	31.3	1,873	0.000
Norway	133	55.6	43.8	129	63.4	47.1	870	0.000
Poland	33	89.7	98.3	41	46.5	42.6	17	1.000
Portugal	34	26.9	23.8	30	37.5	22.5	269	0.000
Spain	63	34.7	28.4	64	29.2	21.2	150	0.007
Sweden	199	48.9	33.3	208	76.8	40.5	1,622	0.000
Switzerland	122	26.7	19.1	116	35.2	20.7	870	0.000
Turkey	136	120.6	119.0	147	125.9	116.7	713	0.000
UK	1,228	38.1	25.8	1,326	67.1	39.5	14,786	0.000
US	3,576	70.3	61.1	4,508	129.5	100.1	50,220	0.000
Euro area	1,560	35.8	25.4	1,923	72.5	38.1	15,111	0.000
Non-Euro Europe	1,954	45.8	30.0	2,074	68.4	41.4	19,763	0.000
Outside Europe	6,302	57.9	45.0	7,542	101.2	66.1	76,874	0.000
All firms	9,816	52.0	38.6	11,539	90.5	57.3	111,748	0.000

Panel B: Regional Portfolios of Firms

	Pre-Euro	Post-Euro	Test for Change	
Region	Variance	Variance	F-test	p-val
Euro area	1.84	3.01	1.6363	0.0001
Non-Euro Europe	1.93	2.82	1.4602	0.0020
Outside Europe	3.84	6.66	1.7368	0.0000

Table 4: Test of Stock Return Variances for Different Firm Quartiles

The table reports the mean and median stock return variances and variance ratios across firms by period, region and quartile. Variances above the 99th percentile, below the 1st percentile and above/below 5 standard deviations of the median variance are excluded from the analysis. The corresponding variance ratios are defined as the variance in the later period divided by the variance of the earlier period. Firms are ranked according to their percent of foreign sales in the Euro area (Panel A), their percentage of foreign sales in Europe (Panel B), their percentage of total foreign sales (Panel C) and their market value (Panel D), respectively. The table reports further the *p*-values of a one-sided Wilcoxon rank sum test of equal variances and variance ratios, respectively ('Wilcoxon').

		Euro Area			Non-Euro Europe			Outside Europe		
Statistic	Quartile	Pre-Euro Variance	Post-Euro Variance	Variance Ratio	Pre-Euro Variance	Post-Euro Variance	Variance Ratio	Pre-Euro Variance	Post-Euro Variance	Variance Ratio
Panel A: Quartiles based on foreign Euro area sales										
Mean	1st	38.40	72.93	1.73	47.35	69.00	1.83	67.57	121.61	1.70
	4th	36.08	70.11	1.31	38.55	45.42	1.43	61.97	118.25	2.00
Median	1st	24.91	34.72	1.15	28.51	39.09	1.23	46.40	69.61	1.35
	4th	17.74	31.40	1.05	25.34	27.57	0.97	49.53	86.26	1.89
Wilcoxon		0.054	0.199	0.135	0.191	0.002	0.007	0.353	0.206	0.014
Panel B: Quartiles based on foreign sales in Europe										
Mean	1st	40.23	82.06	1.85	51.90	71.36	1.69	68.14	122.42	1.69
	4th	37.64	60.54	1.37	39.52	56.41	1.77	59.30	104.45	1.97
Median	1st	25.75	42.35	1.16	30.64	39.26	1.16	46.92	70.33	1.33
	4th	24.01	29.74	1.09	26.11	34.58	1.19	35.52	62.17	1.75
Wilcoxon		0.104	0.002	0.150	0.040	0.030	0.380	0.009	0.070	0.000
Panel C: Quartiles based on total foreign sales										
Mean	1st	44.18	89.35	1.96	60.48	79.80	1.69	70.36	126.17	1.69
	4th	36.80	55.82	1.40	40.42	60.26	1.83	46.86	83.15	1.76
Median	1st	27.90	51.85	1.16	37.25	44.47	1.07	49.00	74.41	1.32
	4th	24.70	29.16	1.11	25.80	34.61	1.29	30.11	41.78	1.50
Wilcoxon		0.007	0.000	0.069	0.000	0.000	0.001	0.000	0.000	0.000
Panel D: Quartiles based on firm size (market capitalization										
Mean	1st	44.93	111.88	2.09	64.15	104.39	2.18	102.30	187.93	1.86
	4th	30.63	38.06	1.66	27.81	37.18	1.73	39.20	64.14	1.82
Median	1st	30.05	77.43	1.29	44.01	67.57	1.28	76.83	134.15	1.40
	4th	19.07	23.20	1.23	18.45	26.08	1.44	27.24	39.18	1.52
Wilcoxon		0.000	0.000	0.086	0.000	0.000	0.145	0.000	0.000	0.000

Table 5: Regressions of Stock Returns on Market Indices

The table reports results of the firm-level regression, $R_{ijt} = \alpha_{ij} + \beta_{ij} R_{Mjt} + \beta_{Euroij} R_{Mjt} D_{Eurot} + \varepsilon_{ijt}$ where R_{ijt} is the return of stock i in country j, R_{Mjt} is the return of the market portfolio in country j, and D_{Eurot} is a dummy variable that takes the value 1 after 1/1/1999 and 0 otherwise. Results are reported by region and quartile, based on foreign Euro area sales (Panel A), foreign sales in Europe (Panel B), total foreign sales (Panel C), and market capitalization (Panel D). For each variable, the median coefficient and the *p*-value ('p-val') of a two-sided sign test are reported. The *Z*-statistic reports a unit normal statistic for a test of the joint significance of the parameter estimates based upon the *t*-statistics for that parameter for each firm in the sample. It is calculated as $Z = \left(\frac{1}{\sqrt{N}}\right)\sum_{i=1}^{N} \frac{t_i}{\sqrt{k_i(k_i-2)}}$, where t_i is the *t*-statistic of the coefficient of firm i, k_i are the degrees of freedom of the regression with firm i, and N is sample size. The corresponding probability of significance is reported in the next column. The table reports further the probability of a two-sided Wilcoxon rank sum test of equal coefficients of firms in the 1st and 4th quartile ("Wilcoxon'). The columns '% sig. +' and '% sig. -.' report the percentage of firms for which the estimated coefficient is significant and positive or negative, respectively.

Panel A: Quartiles based on foreign Euro area sales

						β		β_{Euro}	
Region	Quartile	Median β	p-val	Median β_{Euro}	p-val	%sig.+	%sig.-	%sig.+	%sig.-
Euro area	Q1	0.513	0.000	-0.207	0.000	76.6	0.2	8.1	30.9
	Q4	0.639	0.000	-0.233	0.000	88.4	0.0	4.7	37.2
	Wilcoxon	0.003		0.407					
Non-Euro	Q1	0.440	0.000	-0.064	0.000	66.0	0.1	7.0	16.8
	Q4	0.487	0.000	-0.160	0.000	77.3	0.0	8.0	25.3
	Wilcoxon	0.066		0.020					
Outside	Q1	0.765	0.000	-0.233	0.000	76.6	0.1	6.2	28.4
	Q4	1.169	0.000	-0.241	0.097	92.9	0.0	0.0	21.4
	Wilcoxon	0.007		0.277					
All	Q1	0.662	0.000	-0.193	0.000	74.6	0.1	6.7	26.6
	Q4	0.589	0.000	-0.204	0.000	83.5	0.0	6.0	28.6
	Wilcoxon	0.124		0.371					

Panel B: Quartiles based on foreign sales in Europe

						β		β_{Euro}	
Region	Quartile	Median β	p-val	Median β_{Euro}	p-val	%sig.+	%sig.-	%sig.+	%sig.-
Euro area	Q1	0.466	0.000	-0.169	0.000	73.3	0.2	9.8	26.2
	Q4	0.675	0.000	-0.318	0.000	83.2	0.0	2.7	41.8
	Wilcoxon	0.000		0.000					
Non-Euro	Q1	0.414	0.000	-0.069	0.000	64.2	0.1	6.3	17.1
	Q4	0.531	0.000	-0.108	0.000	72.9	0.0	8.5	22.2
	Wilcoxon	0.000		0.446					
Outside	Q1	0.753	0.000	-0.229	0.000	76.0	0.1	6.2	27.9
	Q4	1.007	0.000	-0.304	0.000	92.0	0.0	3.4	36.4
	Wilcoxon	0.000		0.061					
All	Q1	0.665	0.000	-0.190	0.000	73.8	0.1	6.6	26.0
	Q4	0.603	0.000	-0.204	0.000	78.5	0.0	5.9	31.1
	Wilcoxon	0.002		0.330					

(continued)

Table 5: Regressions of Stock Returns on Market Indices (continued)

Panel C: Quartiles based on foreign sales

						β		β_{Euro}	
Region	Quartile	Median β	p-val	Median β_{Euro}	p-val	%sig.+	%sig.-	%sig.+	%sig.-
Euro area	Q1	0.437	0.000	-0.115	0.000	68.6	0.3	13.4	21.5
	Q4	0.712	0.000	-0.332	0.000	86.9	0.0	3.3	42.8
	Wilcoxon	0.000		0.000					
Non-Euro	Q1	0.439	0.000	-0.065	0.000	65.0	0.1	7.2	17.3
	Q4	0.535	0.000	-0.097	0.000	71.1	0.0	8.3	21.7
	Wilcoxon	0.000		0.262					
Outside	Q1	0.718	0.000	-0.204	0.000	74.2	0.1	6.3	24.9
	Q4	1.021	0.000	-0.473	0.000	93.7	0.0	5.4	54.0
	Wilcoxon	0.000		0.000					
All	Q1	0.672	0.000	-0.176	0.000	72.8	0.1	7.0	23.8
	Q4	0.639	0.000	-0.223	0.000	80.6	0.0	6.5	32.6
	Wilcoxon	0.011		0.000					

Panel D: Quartiles based on company size (market value)

						β		β_{Euro}	
Region	Quartile	Median β	p-val	Median β_{Euro}	p-val	%sig.+	%sig.-	%sig.+	%sig.-
Euro area	Q1	0.290	0.000	-0.134	0.000	53.3	0.5	7.1	19.1
	Q4	0.837	0.000	-0.280	0.000	93.8	0.0	11.5	44.0
	Wilcoxon	0.000		0.000					
Non-Euro	Q1	0.262	0.000	-0.008	0.005	43.2	0.2	6.1	10.2
	Q4	0.682	0.000	-0.197	0.000	92.3	0.0	8.8	31.3
	Wilcoxon	0.000		0.000					
Outside	Q1	0.472	0.000	-0.054	0.000	48.6	0.3	6.3	11.8
	Q4	0.973	0.000	-0.407	0.000	97.8	0.0	6.5	48.2
	Wilcoxon	0.000		0.000					
All	Q1	0.389	0.000	-0.047	0.000	47.1	0.3	6.5	11.8
	Q4	0.915	0.000	-0.359	0.000	96.4	0.0	7.6	45.1
	Wilcoxon	0.000		0.000					

Table 6: Regressions of Stock Returns on Market Indices and Foreign Exchange Rates

The table reports results of the firm-level regression $R_{ijt} = \alpha_{ij} + \beta_{ij} R_{Mjt} + \beta_{Euroij} R_{Mjt} D_{Eurot} + \delta_{ij} R_{FXjt} + \delta_{Euroij} R_{FXjt} D_{Eurot} + \varepsilon_{ijt}$, where R_{ijt} is the return of firm i in country j, R_{Mjt} is the return of the market portfolio in country j, R_{FXjt} is the percentage change of a trade-weighted exchange rate index for country j, and D_{Eurot} is a dummy variable that takes the value 1 after 1/1/1999 and 0 otherwise. Results are reported by region and quartile, based on foreign Euro area sales (Panel A), foreign sales in Europe (Panel B), total foreign sales (Panel C), and market capitalization (Panel D). For each variable, the median coefficient and the *p*-value of a two-sided sign test are reported. The *Z*-statistic reports a unit normal statistic for a test of the joint significance of the parameter estimates based upon the *t*-statistics for that parameter for each firm in the sample. It is calculated as $Z = \left(\frac{1}{\sqrt{N}}\right)\sum_{i=1}^{N} \frac{t_i}{\sqrt{k_i(k_i-2)}}$, where t_i is the *t*-statistic of the coefficient of firm i, k_i are the degrees of freedom of the regression with firm i, and N is sample size. The corresponding probability of significance ('p-val') is reported in the next column. The tables report further the probability of a two-sided Wilcoxon rank sum test of equal coefficients of firms in the 1st and 4th quartile ('Wilcoxon'). The columns '% sig. +' and '% sig. -' report the percentage of firms for which the estimated coefficient is significant and positive or negative, respectively.

Panel A: Quartiles based on foreign Euro area sales

										β		β_{Euro}		δ		δ_{Euro}	
Region	Quartile	Median β	p-val	Median β_{Euro}	p-val	Median δ	p-val	Median δ_{Euro}	p-val	%sig.+	%sig.-	%sig.+	%sig.-	%sig.+	%sig.-	%sig.+	%sig.-
Euro Area	Q1	0.513	0.000	-0.209	0.000	-0.073	0.000	0.150	0.000	75.4	0.2	7.7	31.2	3.6	5.2	3.9	0.2
	Q4	0.650	0.000	-0.228	0.000	-0.240	0.001	-0.128	0.423	88.4	0.0	2.3	37.2	0.0	7.0	2.3	0.0
	Wilcoxon	0.003		0.324		0.063		0.327									
Non-Euro	Q1	0.393	0.000	-0.067	0.000	-0.061	0.000	0.149	0.000	61.8	0.1	6.8	16.7	2.8	6.8	4.4	0.1
	Q4	0.482	0.000	-0.180	0.000	0.057	0.457	0.178	0.000	74.3	0.0	5.4	24.3	4.1	6.8	6.8	0.0
	Wilcoxon	0.011		0.027		0.069		0.143									
Outside	Q1	0.767	0.000	-0.240	0.000	-0.034	0.000	0.040	0.000	76.9	0.1	6.2	28.6	4.7	5.9	4.1	0.1
	Q4	1.168	0.000	-0.245	0.100	-0.155	0.036	0.252	0.080	92.9	0.0	0.0	21.4	0.0	0.0	7.1	0.0
	Wilcoxon	0.007		0.274		0.071		0.127									
All	Q1	0.658	0.000	-0.199	0.000	-0.042	0.000	0.068	0.000	74.1	0.1	6.5	27.0	4.2	5.9	4.1	0.1
	Q4	0.577	0.000	-0.208	0.000	-0.054	0.012	0.157	0.001	80.9	0.0	3.8	28.2	2.3	6.1	5.3	0.0
	Wilcoxon	0.167		0.407		0.259		0.045									

Panel B: Quartiles based on foreign sales in Europe

										β		β_{Euro}		δ		δ_{Euro}	
Region	Quartile	Median β	p-val	Median β_{Euro}	p-val	Median δ	p-val	Median δ_{Euro}	p-val	%sig.+	%sig.-	%sig.+	%sig.-	%sig.+	%sig.-	%sig.+	%sig.-
Euro Area	Q1	0.467	0.000	-0.170	0.000	-0.097	0.000	0.153	0.000	71.9	0.2	9.5	26.3	3.3	5.8	3.9	0.2
	Q4	0.691	0.000	-0.332	0.000	-0.058	0.001	0.302	0.003	84.7	0.0	2.2	43.2	2.7	6.0	4.9	0.0
	Wilcoxon	0.000		0.000		0.444		0.192									
Non-Euro	Q1	0.342	0.000	-0.075	0.000	-0.082	0.000	0.148	0.000	58.3	0.1	5.6	17.5	2.1	7.7	4.9	0.1
	Q4	0.507	0.000	-0.093	0.000	0.054	0.017	0.120	0.000	70.0	0.0	7.8	21.6	5.7	4.6	5.7	0.0
	Wilcoxon	0.000		0.493		0.000		0.440									
Outside	Q1	0.756	0.000	-0.235	0.000	-0.034	0.000	0.040	0.000	76.4	0.1	6.2	28.1	4.4	5.9	4.0	0.1
	Q4	1.006	0.000	-0.315	0.000	-0.059	0.374	-0.012	0.355	92.0	0.0	2.3	36.4	6.8	3.4	6.8	0.0
	Wilcoxon	0.000		0.059		0.447		0.459									
All	Q1	0.663	0.000	-0.199	0.000	-0.046	0.000	0.062	0.000	73.6	0.1	6.5	26.5	4.0	6.1	4.1	0.1
	Q4	0.626	0.000	-0.201	0.000	0.001	0.371	0.110	0.000	78.3	0.0	5.1	31.0	4.9	4.9	5.6	0.0
	Wilcoxon	0.225		0.466		0.015		0.010									

(continued)

Table 6: Regressions of Stock Returns on Market Indices and Foreign Exchange Rates (continued)

Panel C: Quartiles based on foreign sales

										β		β_{Euro}		δ		δ_{Euro}	
Region	Quartile	Median β	p-val	Median β_{Euro}	p-val	Median δ	p-val	Median δ_{Euro}	p-val	%sig.+	%sig.-	%sig.+	%sig.-	%sig.+	%sig.-	%sig.+	%sig.-
Euro Area	Q1	0.445	0.000	-0.123	0.000	-0.083	0.000	0.172	0.001	66.5	0.4	13.0	21.7	3.2	6.3	4.2	0.4
	Q4	0.709	0.000	-0.361	0.000	-0.001	0.175	0.153	0.015	87.6	0.0	3.1	44.4	4.8	4.3	5.0	0.0
	Wilcoxon	0.000		0.000		0.096		0.425									
Non-Euro	Q1	0.326	0.000	-0.070	0.000	-0.069	0.000	0.113	0.000	55.2	0.2	6.2	17.3	2.9	8.4	4.8	0.2
	Q4	0.514	0.000	-0.093	0.000	0.053	0.002	0.148	0.000	70.3	0.0	8.5	21.6	4.8	4.0	4.4	0.0
	Wilcoxon	0.000		0.278		0.000		0.262									
Outside	Q1	0.721	0.000	-0.209	0.000	-0.033	0.000	0.027	0.000	74.7	0.1	6.4	25.1	4.2	5.5	3.8	0.1
	Q4	1.018	0.000	-0.475	0.000	-0.042	0.002	0.116	0.000	93.6	0.0	5.0	54.3	8.2	8.7	6.4	0.0
	Wilcoxon	0.000		0.000		0.128		0.000									
All	Q1	0.669	0.000	-0.182	0.000	-0.038	0.000	0.042	0.000	72.4	0.1	6.9	24.1	4.0	5.8	3.9	0.1
	Q4	0.835	0.000	-0.343	0.000	-0.017	0.191	0.132	0.000	85.7	0.0	5.5	42.9	6.5	6.4	5.5	0.0
	Wilcoxon	0.000		0.000		0.000		0.000									

Panel D: Quartiles based on company size (market value)

										β		β_{Euro}		δ		δ_{Euro}	
Region	Quartile	Median β	p-val	Median β_{Euro}	p-val	Median δ	p-val	Median δ_{Euro}	p-val	%sig.+	%sig.-	%sig.+	%sig.-	%sig.+	%sig.-	%sig.+	%sig.-
Euro Area	Q1	0.287	0.000	-0.132	0.000	-0.051	0.001	0.192	0.002	52.6	0.5	6.6	18.8	2.7	4.8	4.6	0.5
	Q4	0.837	0.000	-0.291	0.000	-0.059	0.047	0.051	0.237	93.7	0.0	10.4	45.3	6.3	6.5	4.1	0.0
	Wilcoxon	0.000		0.000		0.353		0.176									
Non-Euro	Q1	0.228	0.000	0.010	0.448	-0.051	0.000	0.099	0.000	35.4	0.2	6.4	8.4	2.0	4.9	4.9	0.2
	Q4	0.685	0.000	-0.190	0.000	-0.006	0.487	0.156	0.000	91.8	0.0	8.4	31.1	5.9	5.9	4.9	0.0
	Wilcoxon	0.000		0.000		0.014		0.200									
Outside	Q1	0.476	0.000	-0.056	0.000	-0.050	0.000	0.019	0.403	49.0	0.3	6.6	12.2	2.7	4.7	3.2	0.3
	Q4	0.973	0.000	-0.410	0.000	-0.032	0.002	0.040	0.003	97.8	0.0	6.3	48.4	7.5	7.3	5.2	0.0
	Wilcoxon	0.000		0.000		0.000		0.172									
All	Q1	0.386	0.000	-0.055	0.000	-0.051	0.000	0.058	0.001	47.0	0.3	6.6	12.5	2.5	4.8	3.7	0.3
	Q4	0.906	0.000	-0.355	0.000	-0.031	0.002	0.058	0.000	96.1	0.0	7.3	44.7	7.1	6.9	5.0	0.0
	Wilcoxon	0.000		0.000		0.000		0.311									

Table 7: Analysis of Changes in Leverage

The table shows the mean leverage ratio and the corresponding number of firms before and after the introduction of the Euro in 1999. Leverage is calculated for each firm as the average of the end of year ratio of firm value (market value of equity plus book value of debt) to the market value of equity for the period 1993-1998 (pre-Euro) and 1999-2001 (post-Euro). The table presents the *p*-values of two-sample *t*-tests that the means are different across periods. Further, the median of leverage is calculated by period, and *p*-values of one-sided two-sample median tests are presented.

	Pre-Euro Leverage			Post-Euro Leverage			Test for Change	
							On Means	On Medians
Country	N	Mean	Median	N	Mean	Median	p-val	p-val
Austria	66	4.62	2.68	68	7.19	2.91	0.01	0.15
Belgium	81	2.35	1.70	96	2.41	1.62	0.06	0.41
Denmark	115	2.56	1.90	109	3.18	2.14	0.10	0.07
Finland	69	2.74	2.18	79	2.76	1.88	0.98	0.07
France	462	2.78	2.03	457	2.37	1.79	0.08	0.01
Germany	424	3.40	2.19	630	4.09	1.59	0.00	0.00
Greece	67	1.84	1.53	43	1.16	1.13	0.00	0.00
Ireland	50	2.18	1.72	53	2.21	1.75	0.63	0.46
Italy	92	4.14	2.27	79	2.92	1.84	0.01	0.10
Japan	2475	3.49	2.50	3016	4.26	2.70	0.00	0.00
Luxembourg	11	7.77	1.98	8	12.92	2.42	0.14	0.14
Netherlands	166	1.98	1.61	169	2.10	1.71	0.10	0.27
Norway	129	2.56	1.80	113	2.36	1.65	1.00	0.26
Poland	30	2.49	1.79	34	2.28	1.91	0.37	0.50
Portugal	32	2.37	2.12	22	2.72	2.23	0.26	0.50
Spain	64	2.26	1.80	52	2.10	1.75	0.77	0.36
Sweden	203	3.03	1.66	192	2.37	1.50	0.14	0.04
Switzerland	127	3.18	2.32	134	2.37	1.75	0.00	0.00
Turkey	133	3.87	1.02	5	1.01	1.00	0.30	0.09
UK	1327	2.44	1.57	1221	2.06	1.55	0.00	0.28
US	3634	2.13	1.42	4969	4.54	1.55	0.00	0.00
Euro area	1584	2.94	1.98	1756	3.20	1.70	0.01	0.00
Non-Euro Europe	2064	2.65	1.59	1808	2.20	1.60	0.28	0.28
Outside Europe	6109	2.68	1.74	7985	4.43	1.86	0.00	0.00
All firms	9757	2.72	1.72	11549	3.90	1.79	0.00	0.00

Table 8: Test of Leverage Changes for Different Firm Quartiles

The table reports the average leverage across firms by period, region and quartile. Leverage is calculated for each firm as the average of the end of year ratio of firm value (market value of equity plus book value of debt) to the market value of equity for the period 1993-1998 (pre-Euro) and 1999-2001 (post-Euro). The table further reports the average ratio of leverage across periods. Firms are ranked according to their percentage of foreign sales in the Euro area (Panel A), their percentage of foreign sales in Europe (Panel B), their percentage of total foreign sales (Panel C) and their market value (Panel D), respectively. The table reports the probability of a one-sided Wilcoxon rank sum test of equal leverage and leverage ratios, respectively ('Wilcoxon').

	Euro Area			Non-Euro Europe			Outside Europe		
	Pre-Euro	Post-Euro	Post-Pre	Pre-Euro	Post-Euro	Post-Pre	Pre-Euro	Post-Euro	Post-Pre
Quartile	Leverage	Leverage	Ratio	Leverage	Leverage	Ratio	Leverage	Leverage	Ratio
Panel A: Quartiles based on foreign Euro area sales									
Q1	2.94	3.26	1.10	2.66	2.19	1.11	2.68	4.44	1.36
Q4	2.74	2.20	1.11	3.27	2.86	0.98	1.75	2.75	1.91
Wilcoxon	0.29	0.42	0.15	0.00	0.01	0.00	0.20	0.45	0.06
Panel B: Quartiles based on foreign sales in Europe									
Q1	2.98	2.89	1.10	2.54	2.27	1.13	2.71	4.39	1.35
Q4	2.86	2.81	1.15	4.60	2.33	1.05	1.65	6.52	1.48
Wilcoxon	0.02	0.00	0.03	0.00	0.32	0.00	0.00	0.14	0.37
Panel C: Quartiles based on total foreign sales									
Q1	3.00	3.10	1.08	2.14	2.20	1.10	2.67	4.12	1.35
Q4	2.79	3.96	1.11	2.20	2.29	1.09	2.78	6.98	1.44
Wilcoxon	0.00	0.00	0.01	0.00	0.47	0.01	0.10	0.26	0.00
Panel D: Quartiles based on company size (market value)									
Q1	4.21	4.15	1.14	4.86	2.55	1.10	3.67	5.15	1.36
Q4	2.49	2.25	1.00	1.89	1.83	1.07	1.87	2.84	1.36
Wilcoxon	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00