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The impact of the introduction of the Euro on foreign exchange rate risk exposures

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Abstract

This paper tests whether significant changes in stock return volatility, market risk, and foreign exchange rate risk exposures took place around the launch of the Euro in 1999. The experiment analyzes weekly returns for 3220 nonfinancial firms from 18 European countries, the United States, and Japan. We find that though the Euro's launch was associated with an increase in total stock return volatility, significant reductions in market risk exposures arose for nonfinancial firms both in and outside of Europe. We show that the reductions in market risk were concentrated in firms domiciled in the Euro area and in non-Euro firms with a high fraction of foreign sales or assets in Europe. The Euro's introduction led to a net absolute decrease in the foreign exchange rate exposure of nonfinancial firms, but these changes are statistically and economically small. We interpret our findings in the context of existing theories of exchange rate risk management.

JEL classification: G3; F4; F3
Keywords: Foreign exchange rates; Exposure; Euro; Corporate finance; Risk management; Derivatives

> "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

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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 et al., 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, 1994; Shapiro, 1974; Dufey, 1972), the apparent discrepancy between theoretical hypotheses and the existing empirical evidence of over 60 studies is still perceived to be an unresolved issue in the finance literature.[2]

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, an important 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.[3] This paper performs a firm-level analysis of changes in overall stock return volatility, its components related to market risk and foreign exchange rate risk, and how they are different for firms with economic activity in Europe compared to control samples, in particular. Moreover, we investigate to what extent the effect of the Euro on multinational firms is a function of firm, industry, and country characteristics.

To this end, this paper benefits from a high degree of detail on geographic segment data on sales and assets 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. To the best of our knowledge, this data has not been used to study foreign exchange rate exposures, which may be important as the pattern of geographic segment sales is economically a crucial determinant of the foreign exchange rate exposure. After all, since the Euro is introduced in a specific set of European countries only, firms with foreign activities in

[2] A plausible explanation for the low significance of exchange rate exposure consists of hedging at the firm level. Bartram et al. (2004) show that 45% of 7263 non-financial firms in 48 countries around the world do use currency derivatives and that the economic risks in the firms' home markets are important determinants of their usage. Given the variety of methods for hedging, including foreign currency debt, derivatives, operative hedges, pass-through, etc., however, the importance of this effect is difficult to assess empirically.

[3] See the European Commission's (1985) White Paper (EC85), especially Part 2.IV on the removal of technical barriers in financial services. See also its 1992 White Paper (SEC92-2472) on removing the obstacles to a common currency and Part 2.III of the 1995 Green Paper (EC95) on the practicalities of a single currency for enterprises (European Commission 1992, 1995).

these countries are expected to be affected differently by the introduction of the Euro than other firms, and foreign sales or assets in Europe 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 et al. (1996) who study an event with the opposite effect, namely the introduction of flexible exchange rates after the breakdown of the Bretton Woods system. We reverse-engineer their study for the introduction of the Euro with more detailed data on a much larger data set of 3220 firms from 18 European countries, the United States and Japan — one of the largest and broadest studies of foreign exchange rate exposures. Our analysis proceeds in three stages. In the first stage, we show that stock market volatility of many countries and stock return variances of nonfinancial firms increase during the period of analysis. The increase in stock market volatility is lower for firms that have greater Euro currency exposure because they are located in the Euro area compared to firms in Non-Euro Europe and outside of Europe. Moreover, there is little evidence that the increase in stock return volatility is lower for multinational firms with activities in Europe compared to domestic industry-matched and size-matched control firms.

The second stage of our analysis provides results that 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 for firms with economic activity in Europe that are located in and outside of Europe. This finding suggests that foreign exchange rate risk may be an important component of systematic risk. The reduction in market risk is significantly stronger for multinational firms compared to domestic industry- and size-matched control firms, and also for multinational firms with a higher fraction of foreign sales or assets in Europe. Although the effect on market betas could in principle also result from changes in financial leverage, we test for this effect and the evidence does not support this alternative explanation.

The third stage of our analysis focuses on the measurement of incremental foreign exchange rate exposures even after accounting for market risks. Only about 10% of the firms in our large, international sample have significant incremental foreign exchange rate exposures. Among those firms, however, the introduction of the Euro led to a net *absolute* decrease in the foreign exchange rate exposure of nonfinancial multinational firms. That is, those with significant positive (negative) exposures prior to the Euro experienced a significant decrease (increase) after the introduction of the Euro. The changes in these exposures are small in magnitude, on average, but are larger for firms with foreign business in Europe compared to domestic control firms.

Consistent with economic intuition and theory, the changes of market and foreign exchange rate betas of multinationals are shown to be a function of firm characteristics such as total sales, the fraction of foreign sales in general and in Europe in particular. Moreover, geography (i.e. region) and the strength of the local currency before the common currency, as well as industry factors such as competition and trade are important determinants of the impact of the Euro on market and foreign exchange rate betas. Specifically, the reduction in foreign exchange rate exposure is larger for multinationals with lower overall sales, but with a higher fraction of foreign sales in general and in Europe in particular. Furthermore, market betas decrease more for multinationals in the Euro area and in stronger-currency EMU countries (like Germany and France) than in Non-Euro Europe. The change in foreign exchange rate exposure is largest for multinationals in the Euro area, followed by those in Non-Euro Europe, and those outside Europe, underlining the observation that the launch of the common currency had the strongest effect on firms with exposure located in the Euro zone. Consistent with the finding of industry competition as a relevant factor for exposure (Williamson, 2001; Allayannis and Ihrig, 2001;

Bodnar et al., 2002), firms in more competitive industries and those that are based on traded goods show larger reductions in their market and, to a weaker extent, in their foreign exchange rate betas.

The empirical results have important policy implications as they demonstrate the benefits of currency stabilization for nonfinancial companies around the world. With lower market and foreign exchange rate exposures, nonfinancial firms benefit from increased potential to carry higher business risk or to sustain more financial leverage. 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 two recent studies of European firms by Bris et al. (2003, 2006) that the introduction of the Euro is associated with significant increases in Tobin's *Q* and in investment activity.

Other related studies show that the introduction of the Euro was an important event along other economic dimensions as well. Using regime-switching models, Billio and Pelizzon (2002) find that stock market volatility increased in Germany, but decreased in Spain and Italy, which is consistent with findings in Morana and Beltratti (2002) and economic theory that the stabilization of fundamentals translates into lower stock return volatility for historically unstable stock markets. Moreover, Rajan and Zingales (2003) show that the Euro had an economically and statistically significant impact on European bond markets, where the amount of net debt issues almost tripled after the introduction of the common currency.

Lopez and Papell (in press) show statistical evidence of Purchasing Power Parity in the Euro zone starting in the late 1990s, while several studies, such as Flam and Nordström (2003), Micco et al. (2003), Bun and Klaassen (2002), and Barr et al. (2003), document significant increases in trade between Euro countries as well as trade with outside countries after the introduction of the Euro. Fratzscher (2002) identifies the reduction and elimination of exchange rate volatility as a main driver of the integration of equity markets among EMU members. More generally, Galati and Tsatsaronis (2003) and Danthine et al. (2001) conclude that the Euro has had a significant positive effect on European capital markets, though less through direct effects of reduced currency risk than through indirect feedback mechanisms. In contrast, others (e.g. Adjaouté and Danthine, 2003) suggest that the Euro would have a minor impact on equity markets since the currency component in Euro area equity returns has historically been small.

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. Section 4 offers a discussion of the results and alternative interpretations, while Section 5 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 et al., 1996, 1998, 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 et al., 1993; Géczy et al., 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 seeks an alternative approach and methodology (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).

Analyses of portfolios constructed of firms, say, in the same industry show similar results. For example, 20% and 35% of the industry portfolios in Jorion (1990, 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. 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 and 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. Others have suggested that the foreign exchange rate exposure may be in part nonlinear, e.g. due to corporate cash flows being a nonlinear function of foreign exchange rates, real or financial options at the firm level, and thus not be captured by traditional approaches to estimate foreign exchange rate exposures (Bartram, 2004).

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 UK, 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 et al. (2005) conduct a comprehensive study that confirms the evidence of previous investigations on a global scale.

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 et al. (1996) in which they consider 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 5-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 in the context of the introduction of the Euro. We group firms according to industry, geography, and degree of multinationality, and especially the extent to which they have foreign business activities in Europe regardless of where they are domiciled. It is critical in order to investigate our central hypothesis that reductions in foreign exchange rate exposures following the launch of the Euro should obtain for those nonfinancial firms that are domiciled in Euro-area countries and for those domiciled outside the Euro area that have a significant fraction of their foreign sales or assets in the Euro area. 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. In order to accommodate the fact that the introduction of the Euro may have been anticipated to some extent, we follow other papers, such as Bris et al. (2003), and use January 1, 1998 as the effective event date.[4]

Foreign sales have been shown to be a determinant of foreign exchange rate exposures of nonfinancial firms (Jorion, 1990; Bodnar and Wong, 2003). Therefore, out of a sample of 12,821 nonfinancial firms in OSIRIS with data on geographic segment sales and assets as well as stock returns, we select all firms with foreign sales or foreign assets in Europe.[5] There are a total of 1818 such firms, henceforth referred to as "Multinational firms." In order to benchmark the effects of the Euro on the test sample of multinational firms, we select two non-overlapping samples of control firms. First, a control group of firms is selected from 7646 nonfinancial firms that do not have any foreign sales or assets in Europe. They are matched with the multinational 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").[6] Subsequently, for each firm in the multinational sample the area-matched firm is retained that is closest in terms of size as measured by market capitalization to form the size control sample. We refer to these benchmark firms as our "Size control firms."

Second, a sample of firms is selected that are in the same industry as the multinational firms but do not have any foreign sales or assets in Europe ("Industry control firms"). They are matched with the multinational firms by industry and area (Euro area, Non-Euro Europe, Outside Europe). The industry group to which a firm belongs is defined according the highest level of sector detail

[4] Survey evidence discussed in Danthine et al. (2001) suggests that there was a consensus among financial and economic forecasters about the introduction of the Euro and the relevant countries in January 1998. Since the Euro membership of Greece was determined later than for the other Euro countries, Greece is excluded from the analysis. In the robustness section (Section 4.6), we discuss results of alternative sample periods and alternative dates for the introduction of the Euro.

[5] We intentionally exclude from the sample of control firms 3357 firms in the Telecom, Media and Technology (TMT) sector in order to isolate the potentially perturbing effect of the rise/fall of the internet sector stocks on these firms (Ofek and Richardson, 2003). In an earlier version of this paper, we included a control sample of TMT firms matched according to their region of domicile (Euro area, Non-Euro Europe, or Outside Europe) and in terms of the fraction of foreign sales activity. These results are available from the authors upon request.

[6] It is important to recognize the fact that we limit the number of firms outside Europe to include only those from the US and Japan. It is a compromise choice, but our rationalization for it stems in part from the fact that these two markets dominate the capitalization of world markets outside Europe and that they dominate the trade flows between Europe and the rest of the world.

(Level 6) using the classification scheme in Datastream International. Subsequently, for each firm in the multinational sample, the industry- and area-matched firm that is retained is the one closest in terms of size. The matching procedure for both of the non-overlapping size and industry control samples is successful for 701 firms in the test sample of multinational firms.

As a first approach, we follow Bartov et al. (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 of multinational firms compared to industry and size control sample firms 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/assets in Europe. While exchange rate exposures may result from competitive effects as well (Williamson, 2001; Bodnar et al., 2002), 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. Our first testable hypothesis, therefore, follows as:

H1. Nonfinancial firms that are domiciled in Euro area countries and/or those domiciled outside the Euro area that have foreign sales/assets in Euro area countries should exhibit a larger reduction in stock return volatility than firms with no foreign sales/assets in the Euro area.

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 et al. (1996), this statistic is asymptotically distributed Chi-squared with $2N$ 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 conducted separately for firms in the test and control samples. Wilcoxon rank-sum tests, mean tests and median tests are performed across subperiods and samples 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 could thus translate into lower market betas. This effect is expected to be bigger for the sample of multinational firms given their foreign sales/assets in Europe than for the samples of industry and size control firms. Our second testable hypothesis follows as:

H2. Nonfinancial firms that are domiciled in Euro area countries and/or those domiciled outside the Euro area that have foreign sales/assets in Euro area countries should exhibit a larger reduction in market risk exposures than firms with no foreign sales/assets in the Euro area.

The following regression model is estimated with OLS:

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

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 1/1/1998 and 0 otherwise. Standard errors are corrected for autocorrelation and heteroscedasticity with the Newey-West procedure. Results are analyzed for multinational firms and the three control samples by region. In addition to median coefficients and associated p-values, 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 et al. (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 and Chi-squared 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 exchange rate exposures following Adler and Dumas (1984). To the extent that foreign exchange rate risk is not wholly diversifiable and that the lower foreign exchange rate risks do not translate into lower market betas, we would expect to observe lower incremental foreign exchange rate exposures for multinational firms within and outside the Euro area with high foreign sales/assets in the Euro area. Our third testable hypothesis follows as:

H3. Nonfinancial firms that are domiciled in Euro area countries and/or those domiciled outside the Euro area that have foreign sales/assets in Euro area countries should exhibit a larger reduction in incremental foreign exchange rate risk exposures than firms with no foreign sales/assets in the Euro area.

The corresponding regression model is specified as:

$$R_{ijt} = \alpha_{ij} + \beta_{ij}R_{Mjt} + \beta_{Euroij}R_{\mathrm{M}jt}D_{Eurot} + \delta_{ij}R_{FXjt} + \delta_{Euroij}R_{FXjt}D_{Eurot} + \varepsilon_{ijt}, \tag{4}$$

where R_{ijt} is the return of firm i in country j, $R_{\mathrm{M}jt}$ 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, 1998 and 0 before that date. As before, standard errors are corrected with the Newey-West procedure. Median coefficients as well as Z-statistics are 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 different samples are performed. Moreover, the fractions of firms with significant positive or negative exposure coefficients before the Euro (δ_{ij}) are reported separately in order to assess the economic significance and direction of the estimated effects.

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 3220 publicly traded nonfinancial firms from

18 European countries the United States of America, and Japan. All firms are classified into different industry sectors on the basis of the most detailed Datastream industrial classification (Level 6), 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 and assets, 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 (4433) compared to Worldscope (3106), and also the total number of covered firms in Europe is larger (6202 vs. 5351).[7] 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 the Euro area are expected to be affected differently by the introduction of the Euro than other firms, and foreign sales or assets in Europe proxy for this Euro currency exposure.[8]

As indicated above, we define the sample of multinational firms based on foreign sales and foreign assets in Europe. Foreign sales are defined as all sales in geographic segments other than the domestic market. 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 foreign 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. 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 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. The calculation for percentages of foreign assets is analogous.

Table 1 provides descriptive statistics of the test sample of multinational firms as well as the size, and industry control samples. In particular, the samples are compared in terms of market capitalization, sales, total assets, the percentage of total foreign sales, and foreign sales in Europe as a fraction of total sales. The median multinational firm has 23.5% foreign sales in Europe, but there are significant differences across regions: median foreign Europe sales are 33.9% for firms

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

[8] It is important to note that we focus on foreign sales or assets in Europe as a proxy for this Euro currency exposure though we have finer segment data on sales and assets specific to Euro-area countries from OSIRIS. This choice stems from the fact that the much smaller breadth of the sample with such finer segment data. Earlier versions of the paper document the extent of the differences in subsamples and are available from the authors upon request.

Table 1
Descriptive statistics of firms in test and control samples

		N	Market capitalization			Sales			Total assets			Foreign sales			Foreign Europe sales		
			Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
Euro area	Multinationals	218	49.0	193.6	692.0	104.7	312.1	1,103.8	92.6	273.6	940.9	36.3	59.1	82.7	21.6	33.9	51.9
	Size controls	218	48.8	157.0	477.2	61.8	212.1	587.3	90.3	213.4	576.0	0.0	0.0	24.4	0.0	0.0	0.0
	Industry controls	218	9.7	20.3	32.6	21.1	54.5	136.3	23.2	48.9	115.7	0.0	0.0	20.4	0.0	0.0	0.0
Non-Euro Europe	Multinationals	270	26.2	102.8	410.1	53.1	177.6	664.7	44.2	131.8	588.4	19.6	52.9	80.7	9.6	24.1	49.7
	Size controls	270	26.2	100.3	286.1	34.2	117.7	491.2	29.1	121.0	467.7	0.0	0.0	0.0	0.0	0.0	0.0
	Industry controls	270	7.4	14.7	28.8	8.2	32.8	77.1	9.1	24.1	62.4	0.0	0.0	0.0	0.0	0.0	0.0
Outside Europe	Multinationals	213	673.6	2,378.7	7,668.6	814.3	2,287.0	7,546.7	1,022.7	3,026.5	7,910.3	24.3	37.5	60.6	9.3	15.5	24.6
	Size controls	213	674.5	2,394.4	7,686.7	638.9	2,303.3	7,147.6	697.8	2,425.8	8,744.8	0.0	0.0	7.2	0.0	0.0	0.0
	Industry controls	213	213.6	773.8	2,192.3	678.6	1,674.6	4,216.9	570.6	1,455.7	3,707.2	0.0	0.0	1.0	0.0	0.0	0.0
All firms	Multinationals	701	58.1	286.8	1,802.5	101.3	460.4	2,229.6	82.6	412.5	2,193.6	24.8	49.1	78.4	12.1	23.5	41.5
	Size controls	701	58.3	229.6	1,512.6	73.9	324.2	1,547.7	90.6	328.0	1,808.6	0.0	0.0	8.4	0.0	0.0	0.0
	Industry controls	701	12.0	29.0	177.0	22.9	82.9	752.0	20.9	70.1	605.3	0.0	0.0	4.7	0.0	0.0	0.0

The table reports statistics on the test sample of multinational firms and the control samples. Multinationals are nonfinancial firms that have positive values for foreign sales or assets in Europe and that are not in the Telecom, Media, Technology/Internet (TMT) sector. Size controls are nonfinancial firms without foreign sales and assets in Europe outside the TMT sector that are matched with the multinationals by area (Euro area, Non-Euro Europe, Outside Europe). Subsequently, for each firm in the multinational sample the area-matched firm is retained that is closest in terms of size. Industry controls are nonfinancial firms without foreign sales and assets in Europe outside the TMT sector that are matched with the multinationals by industry and area (Euro area, Non-Euro Europe, Outside Europe). Subsequently, for each firm in the multinational sample the industry- and area-matched firm is retained that is closest in terms of size. The table reports by area and sample the number of firms (*N*), as well as market capitalization (in million Euros), sales (in million Euros), total assets (in million Euros), the percentage of foreign sales, and the percentage of foreign sales in Europe. Q1 refers to the 25% quartile, Q2 to the 50% quantile or median, and Q3 to the 75% quartile. Industry definitions are based on the highest level of sector detail (Level 6) in Datastream.

in the Euro area, 24.1% for firms in Non-Euro Europe, and only 15.5% for firms outside of Europe. Size control firms are relatively close to multinational firms in terms of market capitalization, sales and total assets. For example, the median multinational firm has a market capitalization of €286.8 million, sales of €460.4 million and total assets of €412.5 million, compared to the median size control firm with market capitalization of €229.6 million, sales of €324.2 million and total assets of €328.0 million. Multinationals tend to be large firms and, as a result, the firms in the multinational sample have higher market capitalization, sales, and total assets compared to the industry control sample across all regions.[9]

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.[10] We compute weekly returns based on Friday-to-Friday closing prices and quotes.

4. Results

4.1. Stock return volatility

Descriptive statistics (means and variances) of returns stock market indices are presented in Table 2 for the full period (1990–2001) and for the two relevant subperiods before and after the introduction of the Euro. Volatility increases for stock market indexes in many countries after the introduction of the Euro. The largest increases occur in Finland and Turkey. Even the capitalization-weighted world market index return volatility almost doubled during this period. At the same time, there are a few countries where stock return variances are smaller after the Euro, such as Austria and Poland. 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 individual firms (Panel A) as well as for equally-weighted regional portfolios of the sample and control firms (Panel B). The results are reported separately for firms by region. For individual nonfinancial firms, stock return variances are significantly higher after the introduction of the Euro in the test sample of multinational firms as well as the size and industry control samples. The mean (median) multinational firm in the Euro area has a variance of 23.7 (18.3) in the pre-Euro period and 38.0 (26.9) in the post-Euro period. (Note that these are raw weekly return variances in squared percentages; that is, an 18.3 weekly variance corresponds to an annualized 30.8% standard

[9] Others, such as Bartov et al. (1996) and Fatemi (1984), have documented similar size differences between domestic and multinational firms in similar lines of business.

[10] 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} indicates a dollar depreciation." (page 335). Bartov et al. (1996), in contrast, use "…the foreign currency value of the U.S. dollar…)" (page 111). One possible methodological concern is that changes in foreign exchange rate exposures may stem in part from changes over time in the trade weights used by the Bank of England. The weights are computed from three components related to bilateral import competitiveness, bilateral export competitiveness, and competition in manufactured goods between two countries in third-country markets. The original weights reflect trade flows in manufactured goods between 1989 and 1991 and the indexes based on these weights are what we use. But, new indexes have been developed that are now adjusted annually based on trade flows data. However, even with these, the weights adjust little. As an example, the historical country set of weights for the Sterling's exchange rate index available in "The Bank of England's New Sterling Exchange Rate Index (ERI)" (Annex A, Bank of England Media Release dated August 4, 2005) shows that the trade weights for the Euro vary over the period 1979 through 2003 from a high of 56.7% in 1990 and 52.6% in 1997. See http://www.bankofengland.co.uk/publications/news/2005/045.htm for more details.

Table 2
Descriptive statistics of stock market indices

	1990–2001		1990–1997		1998–2001	
	Mean	Variance	Mean	Variance	Mean	Variance
Austria	0.0518	6.2708	0.0712	6.9137	0.0094	4.8902
Belgium	0.1735	4.0678	0.1855	2.9193	0.1471	6.6088
Denmark	0.2141	4.9297	0.2291	3.8411	0.1812	7.3431
Europe	0.1852	4.6343	0.2384	3.5181	0.0689	7.0887
Finland	0.3169	20.6087	0.2581	10.2759	0.4456	43.3708
France	0.2277	6.5180	0.1886	5.0674	0.3133	9.7253
Germany	0.1717	6.0370	0.1953	4.2994	0.1200	9.8784
Ireland	0.2738	6.2174	0.2900	5.0366	0.2382	8.8398
Italy	0.1641	10.6101	0.1329	9.3980	0.2324	13.3195
Japan	−0.1087	9.7708	−0.1728	9.3353	0.0316	10.7491
Luxembourg	0.3006	5.3159	0.4275	2.5251	0.0933	9.8422
Netherlands	0.2795	4.6755	0.3285	2.7990	0.1723	8.8016
Norway	0.1844	9.6305	0.2591	9.1427	0.0209	10.7128
Poland	−0.0800	31.0928	−0.1521	38.2593	−0.0049	23.7771
Portugal	0.1303	5.4004	0.1965	3.9740	−0.0140	8.5139
Spain	0.2394	8.1144	0.2873	6.8723	0.1345	10.8669
Sweden	0.2568	11.3850	0.2893	8.8582	0.1856	16.9833
Switzerland	0.2559	5.3332	0.3278	3.8630	0.0984	8.5519
Turkey	1.1419	60.0768	1.3645	53.7006	0.6546	74.0394
UK	0.2231	4.2129	0.2750	3.2512	0.1095	6.3268
United States	0.2592	4.9716	0.3187	3.2304	0.1292	8.7946
World	0.1326	4.3254	0.1493	3.3777	0.0961	6.4262

This table reports descriptive statistics for 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 (1/1990–12/1997) and the Euro period (1/1998–8/2001). The stock market indices of Luxembourg and Poland start in 1/1992 and 3/1994, respectively.

deviation per year, which is reasonable given the breadth of the sample in that region.) The associated Chi-squared and Wilcoxon tests easily reject the null hypothesis that the variances in the two periods are equal.[11] There are differences across regions. While pre-Euro stock return variances of multinational firms are similar across regions, post-Euro volatility is larger outside Europe and in Non-Euro Europe compared to the Euro area, offering at least preliminary evidence that firms with greater Euro currency exposure (namely, those located in the Euro area) benefited most through the reduction in exchange rate risk as manifested in lower increases in stock return volatility.

When measured relative to the benchmark control firms, the patterns are somewhat more mixed. In the Euro area, individual stock returns in the benchmark samples are similar to those of the multinationals, but are significantly less volatile than the industry control sample after the introduction of the Euro. To test for differences across multinational and control groups, we compute mean and median variance ratios and evaluate differences with a mean test, median test and a one-sided Wilcoxon rank-sum test. The mean firm variance ratio for multinationals of 1.92 is statistically significantly lower than that of the industry controls at 2.39, but the test based on median variance ratios is not, so it suggests that outliers may be present in the industry control

[11] The magnitudes of the Chi-squared statistics are not comparable to those of Bartov et al. (1996) given our sample is more than 6 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.

Table 3
Analysis of stock return variances

Panel A: Individual firms

		Variances										Variance ratios				
		Pre-Euro				Post-Euro				Test for change						
		Mean	Median	Q1	Q3	Mean	Median	Q1	Q3	Chi	Wilcox	Mean	*p*-value	Median	*p*-value	Wilcox
Euro area	Multinationals	23.7	18.3	13.2	28.2	38.0	26.9	19.4	41.1	0.000	0.000	1.92		1.55		
	Size controls	25.1	18.5	12.4	30.8	39.8	26.9	17.1	45.9	0.000	0.000	1.98	0.782	1.36	0.179	0.088
	Industry controls	25.7	20.0	13.8	32.2	62.9	34.4	20.2	77.3	0.000	0.000	2.39	0.065	1.42	0.205	0.355
Non-Euro	Multinationals	31.2	19.7	12.4	36.2	46.5	32.5	20.2	58.1	0.000	0.000	2.27		1.42		
Europe	Size controls	39.4	19.7	11.6	51.9	52.2	29.5	18.0	66.4	0.000	0.000	1.90	0.063	1.44	0.410	0.071
	Industry controls	59.2	37.9	16.7	90.7	77.0	53.0	23.0	118.2	0.000	0.003	2.35	0.840	1.12	0.000	0.001
Outside	Multinationals	27.1	18.5	12.8	29.5	50.8	34.2	22.5	54.5	0.000	0.000	2.20		1.79		
Europe	Size controls	27.0	21.3	13.2	32.7	44.1	32.4	21.9	50.8	0.000	0.000	1.78	0.007	1.59	0.027	0.001
	Industry controls	30.5	25.6	18.4	36.3	54.7	40.5	26.0	66.9	0.000	0.000	1.92	0.169	1.57	0.017	0.001

Panel B: Portfolios of firms

		Variances		Test for change	
		Pre-Euro	Post-Euro	*F*-test	*p*-value
Euro area	Multinationals	1.86	2.73	1.4668	0.0008
	Size controls	1.49	1.82	1.2184	0.0517
	Industry controls	0.84	1.40	1.6564	0.0000
Non-Euro Europe	Multinationals	2.16	2.54	1.1764	0.0902
	Size controls	2.31	3.43	1.4835	0.0005
	Industry controls	3.95	5.14	1.3036	0.0143
Outside Europe	Multinationals	2.97	4.72	1.5909	0.0001
	Size controls	3.09	3.64	1.1805	0.0857
	Industry controls	4.31	4.75	1.1043	0.2058

Panel A reports distributional statistics of stock return variances across firms by area and sample before and after the introduction of the Euro. For each period, the table reports the mean, median, 25% quartile (Q1) and 75% quartile (Q3). 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 Chi-squared 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 two-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 ("Chi"). The table also shows p-values of nonparametric Wilcoxon tests. It reports further the mean and median stock return variance ratios, defined as the variance in the later period divided by the variance of the earlier period. The table shows the p-values of mean tests, median tests, and a one-sided Wilcoxon rank sum test of equal variance ratios, respectively ('Wilcox'), comparing the control samples with the sample of multinationals. Panel B reports variances of equally weighted portfolios by area and sample. 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 two-sided significance levels of the F-test.

sample. The variance ratios of the multinational sample are insignificantly different from that of the size controls. Similar tests on variance ratios for Non-Euro European and Non-European firms also demonstrate similarly mixed results depending on the benchmark samples. In all cases, the variance ratios are usually indistinguishable relative to size and industry control groups.

The test statistics in Panel A based on mean and median variance ratios of individual firm stock returns ignore the lack of independence across firms and are somewhat unreliable. As a result, we perform tests with equally-weighted portfolios of nonfinancial firms in Panel B. As Bartov et al. point out, however, portfolio tests on the multinationals and control samples will likely suffer from a lack of power because the portfolio is created without distinguishing whether the impact of exchange rate changes on firm value is positive or negative. This matters because offsetting influences across affected firms of an event like the introduction of the Euro will lead to a smaller observed impact of exchange rate variability on portfolio return variability. Nevertheless, the results in Panel B corroborate the results for individual stock returns. They are significantly more volatile for all stocks after the introduction of the Euro: portfolio variances of multinationals increase from 1.86 to 2.73 among Euro firms, from 2.16 to 2.54 among Non-Euro European firms, and from 2.97 to 4.72 among non-European firms.

Portfolios of the control sample firms become similarly more volatile, but the extent to which the variance ratios are higher or lower than the multinational samples differs by region and control group. To illustrate, in the Euro area, the variance ratios of the portfolio of multinationals of 1.47, is exceeded by that of the industry control firms (1.66), but not by the size control firms (1.22). Interestingly, however, the variance ratios of the industry and size control portfolios in Non-Euro Europe are both higher than that of the multinationals, but the opposite is the case for portfolios of firms outside Europe.

Overall, these findings suggest that, despite exchange rate stabilization due to the Euro, stock returns of most nonfinancial firms have evidently become more volatile after the introduction of the common currency.[12] Note that it would be consistent with the conjectures about the foreign exchange rate exposure of multinational firms if these firms had lower increases in stock return volatility compared to control firms. In contrast, while stock market volatility in general and stock return volatility of nonfinancial firms in particular increased after the introduction of the Euro, there is little evidence that firms with foreign business in Europe have significantly lower increases in stock return volatility compared to size and industry control samples.

These findings are interesting and somewhat surprising compared to Bartov et al. (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. In contrast, using a broader set of firms with more detail on their foreign business activities, we find little differences between multinational firms and control firms, or even larger increases in stock return volatility for multinationals compared to industry and size control firms. This is not necessarily inconsistent with Bartov, Bodnar and Kaul, however. We do observe that firms that have greater Euro currency exposure because they are located in the Euro area have lower increases in stock return volatility compared to firms in Non-Euro Europe and outside of

[12] While we exclude TMT firms from the analysis, it is still possible that a TMT "effect" impacts the volatility of all nonfinancial stock returns. Ofek and Richardson (2003) investigate the impact of the rise and fall of internet stock prices. Their Fig. 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. The observed higher volatility in the US after 1999 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 Morck et al. (2000), Campbell et al. (2001), Goyal and Santa-Clara (2003) and Ferreira and Gama (2005).

Europe, which is consistent with the exposure theory. One possible reason for the differences in our findings to now is that our focus on total stock market risk masks the differences in 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 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 and control firms.[13] The detailed geographic segment sales data of the OSIRIS database is exploited here as well by comparing the effects for firms with and without foreign sales and assets in Europe, overall as well as by region. We report the median values and the Z-statistic 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 that the medians are equal to zero as well as p-value of the joint significance of the parameter estimates (Z-statistic), the fraction of statistically significant positive and negative values of β and β_{Euro}, respectively, and Wilcoxon rank-sum and Chi-squared tests that the coefficients across two groups are equal (Table 4).

Multinational firms have median β estimates of 0.55 (Euro area), 0.45 (Non-Euro Europe) and 0.95 (Outside Europe) 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. Compared to the multinationals, size control firms have typically slightly smaller median β estimates of 0.46, 0.44 and 0.88 for the Euro area, Non-Europe, and Outside Europe. The differences between median βs of the test sample of multinational firms and the size control sample are significant in the Euro area and (marginally) outside Europe. Industry control firms have lower βs compared to multinational firms. While all of these differences are significant, they are largest for firms in Europe and smallest for those firms outside of Europe. This is important as it impacts on the magnitude of the declines in βs observed after the introduction of the Euro.

Our results indicate that market risk is significantly reduced for many firms in and outside of Europe after the introduction of the Euro. In particular, the change in market betas (β_{Euro}) is significantly negative as measured by the median coefficients and the Z-statistic, and this result applies for multinational firms as well as size and industry control firms and for all regions of the world. Moreover, multinational firms experience a larger decline than industry and size control firms, no doubt, partly because their βs are higher in the first place.

The declines in market betas of multinational firms, however, are greater than those of size control firms. In the Euro area, multinational firms have β_{Euro} around -0.21 (31% significantly negative, 5% significantly positive), while size control firms have a median β_{Euro} of -0.17 (29% significantly negative, 4% significantly positive). The median values of β_{Euro} for multinationals are -0.12 and -0.36 in Non-Euro Europe and outside Europe, respectively, while the corresponding values for size control firms are -0.10 and -0.41. The differences are, however, not large enough to be significant by the Wilcoxon and Chi-squared tests. Multinational firms also have larger declines in market betas than industry control firms, where the β_{Euro} are -0.08 (Euro

[13] In Section 4.5, we discuss results of robustness tests in which the regression model specifications use a global market index instead of local market indices.

Table 4
Regressions of stock returns on market indices

		Median	p-value	Z-statistic	p-value	Wilcox	Chi	% pos	% neg	Median	p-value	Z-statistic	p-value	Wilcox	Chi	% pos	% neg
		β								β_{Euro}							
Euro area	Multinationals	0.547	0.000	75.3	0.000			82.1	0.0	−0.208	0.000	−16.6	0.000			5.1	30.8
	Size controls	0.459	0.000	67.9	0.000	0.022	0.078	70.7	0.5	−0.174	0.000	−15.1	0.000	0.174	0.290	3.5	29.3
	Industry controls	0.217	0.000	25.3	0.000	0.000	0.000	43.9	0.6	−0.078	0.000	−6.5	0.000	0.001	0.001	5.2	16.1
Non-Euro	Multinationals	0.452	0.000	56.9	0.000			64.5	0.8	−0.115	0.000	−12.0	0.000			6.5	25.0
Europe	Size controls	0.442	0.000	68.6	0.000	0.382	0.687	68.3	0.8	−0.104	0.000	−8.0	0.000	0.107	0.754	7.2	18.1
	Industry controls	0.391	0.000	48.6	0.000	0.003	0.194	54.1	0.5	−0.054	0.090	−3.9	0.000	0.006	0.138	8.3	10.6
Outside	Multinationals	0.951	0.000	124.4	0.000			93.4	0.0	−0.359	0.000	−26.9	0.000			2.4	48.3
Europe	Size controls	0.876	0.000	114.6	0.000	0.120	0.064	90.9	0.0	−0.409	0.000	−27.8	0.000	0.447	0.284	3.3	50.7
	Industry controls	0.901	0.000	112.8	0.000	0.053	0.135	90.1	0.0	−0.347	0.000	−24.1	0.000	0.233	0.765	3.1	44.0

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 1/1/1998 and 0 otherwise. Results are reported by area, sample, and coefficient. 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 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 control sample and the multinationals ("Wilcox'), as well as p-values of a Chi-squared test ('Chi') of equal medians. The columns '% pos.' and '% neg.' report the percentage of significant positive and negative coefficients, respectively.

area), −0.05 (Non-Euro Europe) and −0.35 (Outside Europe). Within Europe, at least, these differences are significant at the 1% level.

Overall, there is 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 nonfinancial firms. In addition, the decrease in market risk is typically greater for firms with important foreign business activities in Europe compared to firms of similar size or in the same industry that have no foreign sales or assets in Europe. 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 et al. (1996) who document significant increases in market risk of U.S. multinationals after the breakdown of the Bretton Woods system when foreign exchange rate risk increased, while market betas of control firms did not change or decreased. 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 et al. (2003) that the introduction of the Euro is associated with significant increases in Tobin's *Q*.

4.3. Changes 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 5, we investigate these incremental exchange rate effects around the introduction of the Euro by estimating Eq. (4) in which the overall foreign exchange rate exposure is given by δ and the change in the exposure after the introduction of the common European currency, by δ_{Euro}. We report similar summary statistics as in Table 4 but only for the foreign exchange rate coefficients (δ, δ_{Euro}), since the results for the market betas and changes in market betas are very similar to those reported in Table 4. In addition, the results are reported separately by positive and negative foreign exchange rate coefficients in the pre-Euro period with their corresponding post-Euro changes in these coefficients, given that exposures to foreign exchange rate risk have different signs. The table shows medians and corresponding *p*-values, *Z*-statistics and associated *p*-values, percentages of significant positive and negative coefficients, Wilcoxon rank-sum, and Chi-squared tests of equality across subgroups.

On the whole, 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 that for changes in market risk. At the same time, the percentage of significantly negative coefficients appears slightly larger than that for significant positive coefficients. Moreover, median positive and negative exposures are of a similar order of magnitude, while larger overall for firms in the Euro area than in Non-Euro Europe and outside of Europe. To illustrate, the fraction of multinational firms with significant coefficients is between 1.6% and 5.2% for positive exposures (δ^+) and between 5.7% and 7.3% for negative exposures (δ^-). Multinational firms in the Euro area have median positive exposures of 0.40 and negative exposures of −0.38. For Non-Euro Europe and outside of Europe, the median positive (negative) coefficients are 0.24 (−0.26) and 0.16 (−0.15), respectively.

Table 5
Regressions of stock returns on market indices and foreign exchange rates

		Median	p-value	Z-statistic	p-value	Wilcox	Chi	% pos	% neg	Median	p-value	Z-statistic	p-value	Wilcox	Chi	% pos	% neg
		δ^{+}								δ^{+}_{Euro}							
Euro area	Multinationals	0.397	0.000	8.4	0.000			4.7	0.0	−0.167	0.337	−2.5	0.007			1.6	2.6
	Size controls	0.324	0.000	7.5	0.000	0.354	0.184	2.0	0.0	−0.344	0.171	−2.7	0.003	0.431	0.481	0.0	2.6
	Industry controls	0.417	0.000	7.6	0.000	0.208	0.590	1.9	0.0	−0.105	1.000	−2.0	0.025	0.354	0.820	0.0	3.2
Non-Euro	Multinationals	0.240	0.000	8.5	0.000			1.6	0.0	−0.217	0.004	−3.3	0.000			0.8	0.8
Europe	Size controls	0.252	0.000	9.2	0.000	0.284	0.771	3.9	0.0	−0.126	0.004	−2.9	0.002	0.401	0.146	0.0	2.4
	Industry controls	0.349	0.000	7.5	0.000	0.045	0.046	1.2	0.0	−0.411	0.000	−5.0	0.000	0.010	0.087	0.0	3.7
Outside	Multinationals	0.163	0.000	9.8	0.000			5.2	0.0	0.029	0.824	−1.3	0.100			0.9	3.3
Europe	Size controls	0.139	0.000	7.5	0.000	0.172	0.267	3.3	0.0	−0.154	0.040	−2.9	0.002	0.036	0.153	1.4	2.9
	Industry controls	0.164	0.000	9.7	0.000	0.488	0.878	6.8	0.0	−0.235	0.003	−4.8	0.000	0.033	0.092	1.0	6.3
		δ^{-}								δ^{-}_{Euro}							
Euro area	Multinationals	−0.377	0.000	−9.8	0.000			0.0	7.3	0.456	0.001	4.2	0.000			2.1	0.0
	Size controls	−0.331	0.000	−9.8	0.000	0.442	0.142	0.0	5.6	0.314	0.010	4.2	0.000	0.250	0.229	4.1	0.0
	Industry controls	−0.370	0.000	−8.0	0.000	0.201	0.881	0.0	2.6	0.528	0.003	4.2	0.000	0.279	0.454	0.0	0.0
Non-Euro	Multinationals	−0.261	0.000	−11.6	0.000			0.0	5.7	0.424	0.000	8.6	0.000			6.9	0.0
Europe	Size controls	−0.218	0.000	−12.4	0.000	0.140	0.416	0.0	9.2	0.303	0.000	7.0	0.000	0.022	0.029	4.4	0.5
	Industry controls	−0.331	0.000	−9.0	0.000	0.488	0.607	0.0	4.9	0.317	0.002	4.3	0.000	0.113	0.424	2.4	0.0
Outside	Multinationals	−0.149	0.000	−10.8	0.000			0.0	5.7	0.260	0.000	8.2	0.000			8.1	0.5
Europe	Size controls	−0.202	0.000	−13.1	0.000	0.075	0.014	0.0	10.5	0.201	0.000	7.2	0.000	0.125	0.324	10.0	1.0
	Industry controls	−0.188	0.000	−10.2	0.000	0.256	0.187	0.0	6.8	0.155	0.022	4.8	0.000	0.039	0.113	6.8	1.0

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 1/1/1998 and 0 otherwise. Results are reported by area, sample, and variable. They are limited to the estimates of the foreign exchange rate coefficients, but reported separately for positive and negative foreign exchange rate betas and corresponding changes. 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 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 control sample and the multinationals ("Wilcox"), as well as p-values of a Chi-squared test ('Chi') of equal medians. The columns '% pos.' and '% neg.' report the percentage of significant positive and negative coefficients, respectively.

Surprisingly, size control firms tend to have similar foreign exchange rate exposures as multinational firms within and outside Europe. The Wilcoxon and Chi-squared tests indicate that the differences are too small to be significant, except for negative exposures outside Europe, which are significantly larger for size control firms (p-values of 0.075 and 0.014, respectively). Firms that are in the same industry as the test sample firms, but do not have foreign sales or assets in Europe, tend to have larger positive and negative foreign exchange rate exposures than the multinationals, but they are insignificantly different by the Wilcoxon and Chi-squared tests.

The finding of negative exposures of multinationals appears counter to economic intuition as it implies that firms experience declines in firm value (relative to the market) when the local currency depreciates.[14] It is, however, consistent with results reported in previous research. For example, 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 (1971–1975), −0.079 (1976–1980) and −0.078 (1981–1987). 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 in Table 5 is that the change in foreign exchange exposure following the introduction of the Euro (δ_{Euro}) is of the opposite sign as the exposure beforehand (δ); in other words, the change is mean-reverting toward zero. For example, for multinational firms in the Euro area, the change in positive exposures (δ^{+}_{Euro}) is −0.17 and the change in negative exposures (δ^{-}_{Euro}) is 0.46. In Non-Euro Europe, the changes for positive and negative exposures are −0.22 and 0.42, respectively, and outside Europe they are 0.03 (not significantly different from zero) and 0.26, respectively. The percentage of significant changes in exposures is very low: for multinational firms, they are between 0.8% and 1.6% (0.8% and 3.3%) for positive (negative) changes of positive exposures; for negative exposures, 2.1% and 8.1% (0.0% and 0.5%) of the positive (negative) changes are significant.

Given that the levels of exposures of size control firms and multinationals were similar, it is not surprising that the changes are close as well. In particular, the change in positive and negative exchange rate exposures of size control firms are −0.34 and 0.31 in the Euro area, −0.13 and 0.30 in Non-Euro Europe, and −0.15 and 0.20 outside of Europe. The Wilcoxon and Chi-squared tests indicate only for size control firms with positive exposures outside Europe (p-values of 0.036 and 0.153) and with negative exposures in Europe but outside the Euro area (p-values of 0.022 and 0.029) significant differences in exposure relative to multinational firms by the Wilcoxon and Chi-squared tests.

Overall, the fraction of significant changes in exposure toward zero from levels before the Euro outnumbers those of significant change toward higher exposure levels, which suggests that this is a pervasive effect across the sample. Considering both, the level and change in the exposure indicates that the introduction of the Euro overall induced a net reduction in foreign exchange rate exposure, which appears in line with economic intuition and theory. Interestingly, the change of the exchange rate exposure in the study by Bartov et al. (1996) also has the opposite sign as the exposure to exchange rate risk before the transition to flexible exchange rates, even though exchange rate risk increased after the breakdown of the Bretton Woods system. However, their analysis does not explicitly consider positive and negative exposures separately.

[14] In contrast, negative signs would be consistent with the exposure of importing firms. In the aggregate, 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.

On the whole, the results indicate that the stabilization of foreign exchange rates, as entailed by the introduction of the Euro, leads to lower market risk exposure for most firms – though especially those with foreign sales or assets in Europe – as well as to lower foreign exchange rate risk exposure in general. In contrast, we find that many firms, even if they have foreign sales and assets, have neither significant levels of incremental foreign exchange rate exposure, nor significant changes in their exposure after the launch of the Euro. Nevertheless, the Euro generally leads to a net reduction of incremental foreign exchange rate exposures.

The finding 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, documents a conceptual challenge 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. Discussion of results and alternative interpretations

Several caveats are in order to put the empirical results into perspective. Most importantly, financial markets are characterized by increased market liberalization, integration, and a 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; De Grauwe, Chapter 1, 2000). 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 significant decreases in the market betas of multinationals 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 systematic risk 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 between these firms and the respective market portfolio leading to corresponding changes in the systematic risk. Bartov et al. (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 many stock markets and nonfinancial firms. In contrast, there is only weak evidence that the increase in volatility for multinationals is significantly lower compared to that for industry or size control firms. At the same time, 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, low significance and reductions of foreign exchange rate exposures could in principle be the results of firms successfully hedging against exchange rate risk with financial and operative risk management strategies. In fact, evidence by Allayannis and Ofek (2001) suggests that firms using derivatives for hedging show lower foreign exchange rate exposures.

As a result, changes in foreign exchange rate exposures could be a function of the changing degree of hedging at the firm level. Nevertheless, there is little information available about changes in actual hedging practices over time, and, to our knowledge, there is no information about whether corporate hedging behavior has significantly changed after the introduction of the Euro. Anecdotal evidence, derivatives statistics by the Bank for International Settlements as well as surveys on derivatives usage (e.g. Bodnar et al., 1998) suggest that an increasing number of firms use derivatives. This could suggest that more firms are hedging over time, so that our Euro dummy variable may pick up a hedging effect rather than a Euro effect. Nevertheless, it is not clear that the number of derivative users has increased so dramatically after the introduction of the Euro to justify such a conclusion. Moreover, derivatives use may often serve as a complement or substitute of other hedging tools firms commonly employ, suggesting that increased derivatives use may not be a good proxy for measuring the numbers of firms that are hedging after the Euro compared to before.

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):

$$\beta = \beta_a \frac{V}{E}. \tag{5}$$

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 and control 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 6 presents means and medians of leverage before and after the introduction of the Euro as well as two-sample t-tests, two-sample median tests, as well as non-parametric Wilcoxon tests for differences across time. Overall, we find that leverage of multinational firms actually increases from a median of 2.10 to 2.27 in the Euro area, from 1.58 to

Table 6
Analysis of changes in leverage

		Leverage											
		Pre-Euro		Post-Euro		Test for change			Leverage ratios				
		Mean	Median	Mean	Median	On means	On medians	Wilcox	Mean	*p*-value	Median	*p*-value	Wilcox
Euro area	Multinationals	2.92	2.10	5.80	2.27	0.92	0.15	0.24	1.11		1.01		
	Size controls	3.67	2.09	3.86	2.17	0.53	0.46	0.48	1.11	0.941	1.00	0.456	0.271
	Industry controls	3.77	2.81	6.09	3.08	0.03	0.17	0.25	1.27	0.108	1.07	0.037	0.090
Non-Euro Europe	Multinationals	2.41	1.58	2.49	1.88	0.66	0.00	0.00	1.23		1.13		
	Size controls	1.85	1.47	2.23	1.73	0.11	0.00	0.00	1.15	0.074	1.06	0.013	0.040
	Industry controls	3.95	1.49	2.92	2.01	0.02	0.00	0.00	1.33	0.185	1.14	0.246	0.070
Outside Europe	Multinationals	1.97	1.63	4.40	1.78	0.05	0.30	0.07	1.32		1.07		
	Size controls	1.95	1.49	2.73	1.69	0.00	0.07	0.03	1.33	0.946	1.06	0.203	0.355
	Industry controls	3.17	2.05	4.30	2.54	0.00	0.02	0.01	1.33	0.909	1.14	0.106	0.061

The table reports distributional statistics on financial leverage across firms by area and sample before and after the introduction of the Euro. For each period, the table shows the mean and median leverage calculated 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 1993–1997 (pre-Euro) and 1998–2001 (post-Euro). The table also presents *p*-values of two-sample *t*-tests that the means are equal across periods. Further, *p*-values of one-sided two-sample median tests as well as of nonparametric Wilcoxon test (‘Wilcox’) of differences in leverage are presented. The table reports further the mean and median leverage ratios, defined as leverage in the later period divided by leverage in the earlier period. The table reports the *p*-values of mean tests, median tests, and a one-sided Wilcoxon rank sum test of equal leverage ratios, comparing the control samples with the sample of multinationals.

1.88 in Non-Euro Europe, and from 1.63 to 1.78 outside of Europe. Except for the Euro area, these increases are also significant.

Since market risk is a relative measure, it has also to be tested whether the change in leverage is significantly different for multinational versus control 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. To this end, Table 6 provides additional tests of leverage across samples based on leverage ratios. When looking at results of Wilcoxon rank sum tests for differences between multinational firms and size control firms, it appears that there are no significant differences between the leverage ratios of both samples of firms, except that leverage increases more for multinational firms in Non-Euro Europe. Size control firms show an increase in leverage in all regions (by medians): From 2.09 to 2.17 in the Euro area, 1.47 to 1.73 in Non-Euro Europe, and 1.49 to 1.69 outside of Europe. Similarly,, leverage of industry control firms appears to increase significantly more than for multinational firms in all regions. Industry control firms show increases in financial leverage in the Euro area (2.81 to 3.08), Non-Euro Europe (1.49 to 2.01), and outside of Europe (2.05 to 2.54), and the changes are significant outside the Euro area. Overall, these results show a mixed pattern of changes in leverage, and the differences across samples appear economically small. As a consequence, there is no strong evidence to support the alternative conjecture that the documented decreases in market risk exposures are simply the reflection of reductions in financial leverage. Results by Bartov et al. (1996) for their sample of U.S. firms also support this view.

4.5. Sensitivity analysis

Our final set of tests further investigates the cross-sectional effect of changes in the foreign exchange rate and market betas induced by the introduction of the Euro. To this end, we provide additional tests based now on all 1818 multinational firms that have foreign sales or assets in Europe. In particular, we investigate subsamples of these firms split by firm characteristics, region, and industry. Table 7 exhibits the results. As before, we report the median values and the Z-statistic of market betas (β) and foreign exchange rate betas (δ) as well as of the changes in the market and exchange rate betas (β_{Euro}, δ_{Euro}) following the introduction of the Euro, p-values of two-sided sign tests that the medians are equal to zero as well as p-value of the joint significance of the parameter estimates (Z-statistic), the fraction of statistically-significant positive and negative coefficient, respectively, and Wilcoxon rank-sum and Chi-squared tests that the coefficients across two groups are equal. Results for the foreign exchange rate betas are split by positive and negative coefficients as previously.

Panel A of Table 7 shows results where multinational firms are split by the median value of total sales, the percentage of total foreign sales, as well as foreign sales in Europe. First, we note that 60% to 90% of the market betas are significantly positive, but multinational firms with above-median sales have larger market betas of 0.844 compared to multinationals with below-median sales (0.368). Similarly, multinational firms with a higher fraction of total foreign sales have larger betas (0.641) than those with a lower fraction of foreign sales (0.524). While the split by sales and the percentage of total foreign sales yields significant differences across subsamples, the extent of foreign sales in Europe does not produce low p-values in the Wilcoxon and Chi-squared tests.

Consistent with the earlier findings, the effect of the introduction of the Euro on market betas is a significant decline, manifested in negative median values for β_{Euro}, significant, negative Z-statistics and a high fraction of significant negative coefficients. But the decrease in market betas

Table 7
Cross-sectional analysis of market and foreign exchange rate betas

	Median	p-value	Z-statistic	p-value	Wilcox	Chi	%pos	%neg	Median	p-value	Z-statistic	p-value	Wilcox	Chi	% pos	% neg
Panel A: Results by firm characteristics																
	β								β_{Euro}							
Sales low	0.368	0.000	74.5	0.000			61.6	0.5	−0.086	0.000	−12.9	0.000			5.6	16.6
Sales high	0.844	0.000	229.7	0.000	0.000	0.000	93.9	0.0	−0.305	0.000	−51.4	0.000	0.000	0.000	2.1	46.1
Total foreign sales low	0.524	0.000	140.3	0.000			75.9	0.4	−0.207	0.000	−32.7	0.000			2.7	31.5
Total foreign sales high	0.641	0.000	164.4	0.000	0.000	0.000	79.5	0.1	−0.186	0.000	−32.1	0.000	0.125	0.471	5.0	31.1
Foreign Europe sales low	0.579	0.000	150.3	0.000			77.0	0.5	−0.211	0.000	−33.2	0.000			3.5	31.7
Foreign Europe sales high	0.576	0.000	154.4	0.000	0.456	0.901	78.8	0.0	−0.186	0.000	−31.9	0.000	0.079	0.203	4.0	31.1
	δ^{+}								δ^{+}_{Euro}							
Sales low	0.242	0.000	15.3	0.000			2.7	0.0	−0.284	0.000	−7.7	0.000			0.2	1.9
Sales high	0.213	0.000	20.3	0.000	0.037	0.375	6.5	0.0	−0.071	0.203	−2.4	0.009	0.000	0.001	1.6	2.6
Total foreign sales low	0.195	0.000	14.8	0.000			3.0	0.0	−0.159	0.000	−5.5	0.000			0.6	2.3
Total foreign sales high	0.256	0.000	20.6	0.000	0.001	0.010	6.3	0.0	−0.177	0.000	−4.7	0.000	0.477	0.799	1.2	2.1
Foreign Europe sales low	0.196	0.000	16.2	0.000			3.6	0.0	−0.102	0.020	−3.7	0.000			1.1	2.5
Foreign Europe sales high	0.246	0.000	19.4	0.000	0.001	0.052	5.7	0.0	−0.228	0.000	−6.2	0.000	0.010	0.052	0.7	2.0
	δ^{-}								δ^{-}_{Euro}							
Sales low	−0.277	0.000	−19.8	0.000			0.0	4.5	0.372	0.000	12.0	0.000			4.2	0.2
Sales high	−0.199	0.000	−20.1	0.000	0.000	0.001	0.0	5.7	0.315	0.000	12.0	0.000	0.029	0.096	6.0	0.4
Total foreign sales low	−0.199	0.000	−21.4	0.000			0.0	5.8	0.278	0.000	11.6	0.000			5.6	0.5
Total foreign sales high	−0.293	0.000	−18.7	0.000	0.000	0.001	0.0	4.5	0.480	0.000	12.7	0.000	0.000	0.000	4.6	0.1
Foreign Europe sales low	−0.196	0.000	−21.3	0.000			0.0	6.1	0.285	0.000	11.8	0.000			5.6	0.6
Foreign Europe sales high	−0.292	0.000	−18.8	0.000	0.000	0.000	0.0	4.2	0.454	0.000	12.3	0.000	0.000	0.001	4.6	0.0
Panel B: Results by region																
	β								β_{Euro}							
Euro area	0.600	0.000	142.3	0.000			82.9	0.0	−0.228	0.000	−33.8	0.000			2.5	35.5
Non-Euro Europe	0.475	0.000	117.5	0.000	0.000	0.000	70.0	0.5	−0.135	0.000	−21.8	0.000	0.000	0.000	5.1	24.1
Outside Europe	0.950	0.000	127.2	0.000	0.000	0.000	92.8	0.0	−0.356	0.000	−27.4	0.000	0.000	0.000	2.7	47.5
EMU strong	0.594	0.000	123.4	0.000			82.5	0.0	−0.235	0.000	−28.7	0.000			2.3	35.5
EMU weak	0.608	0.000	71.2	0.000	0.343	0.743	84.6	0.0	−0.221	0.000	−18.2	0.000	0.467	0.743	3.3	35.8
	δ^{+}								δ^{+}_{Euro}							
Euro area	0.283	0.000	15.1	0.000			5.7	0.0	−0.335	0.001	−5.0	0.000			0.9	2.5
Non-Euro Europe	0.214	0.000	17.5	0.000	0.000	0.016	3.6	0.0	−0.160	0.000	−5.2	0.000	0.029	0.119	0.8	1.6
Outside Europe	0.184	0.000	10.5	0.000	0.000	0.000	5.8	0.0	0.027	0.915	−1.4	0.078	0.027	0.014	1.3	4.0
EMU strong	0.284	0.000	12.9	0.000			4.8	0.0	−0.428	0.000	−5.3	0.000			1.1	2.7
EMU weak	0.279	0.000	8.2	0.000	0.221	0.876	8.9	0.0	0.060	0.576	−0.4	0.348	0.006	0.008	0.0	1.6

	δ^{-}								δ^{-}_{Euro}							
Euro area	−0.343	0.000	−16.0	0.000			0.0	5.0	0.428	0.000	7.0	0.000			2.3	0.4
Non-Euro Europe	−0.212	0.000	−20.8	0.000	0.000	0.000	0.0	5.2	0.337	0.000	13.7	0.000	0.138	0.192	6.3	0.2
Outside Europe	−0.150	0.000	−10.9	0.000	0.000	0.000	0.0	5.4	0.261	0.000	8.1	0.000	0.150	0.029	7.6	0.4
EMU strong	−0.359	0.000	−13.4	0.000			0.0	4.1	0.315	0.001	4.6	0.000			1.6	0.5
EMU weak	−0.295	0.000	−8.9	0.000	0.019	0.054	0.0	8.1	0.513	0.000	6.1	0.000	0.023	0.098	4.9	0.0
Panel C: Results by industry																
	β								β_{Euro}							
Herfindahl sales low	0.561	0.000	183.2	0.000			78.7	0.3	−0.222	0.000	−43.2	0.000			3.2	33.9
Herfindahl sales high	0.598	0.000	104.9	0.000	0.205	0.212	75.1	0.3	−0.148	0.000	−15.8	0.000	0.000	0.002	6.0	24.2
Herfindahl total assets low	0.569	0.000	181.5	0.000			78.0	0.3	−0.210	0.000	−41.1	0.000			3.7	32.4
Herfindahl total assets high	0.586	0.000	108.1	0.000	0.430	0.502	77.1	0.0	−0.177	0.000	−19.3	0.000	0.076	0.165	4.4	28.3
Traded goods	0.578	0.000	163.1	0.000			78.0	0.1	−0.205	0.000	−36.0	0.000			3.9	32.7
Non-traded goods	0.575	0.000	140.9	0.000	0.362	0.939	77.2	0.4	−0.191	0.000	−28.4	0.000	0.091	0.471	3.8	29.7
	δ^{+}								δ^{+}_{Euro}							
Herfindahl sales low	0.201	0.000	20.0	0.000			4.1	0.0	−0.177	0.000	−6.0	0.000			0.9	2.1
Herfindahl sales high	0.271	0.000	13.9	0.000	0.019	0.021	5.5	0.0	−0.189	0.003	−4.0	0.000	0.275	0.798	0.8	2.3
Herfindahl total assets low	0.207	0.000	20.0	0.000			4.1	0.0	−0.169	0.000	−5.7	0.000			0.8	2.0
Herfindahl total assets high	0.243	0.000	13.9	0.000	0.054	0.066	5.7	0.0	−0.276	0.001	−4.5	0.000	0.131	0.335	1.1	2.5
Traded goods	0.232	0.000	21.0	0.000			6.1	0.0	−0.179	0.000	−4.8	0.000			0.9	1.8
Non-traded goods	0.217	0.000	14.5	0.000	0.125	0.624	2.8	0.0	−0.154	0.003	−5.4	0.000	0.361	0.687	0.9	2.7
	δ^{-}								δ^{-}_{Euro}							
Herfindahl sales low	−0.222	0.000	−24.0	0.000			0.0	5.1	0.345	0.000	15.2	0.000			5.4	0.4
Herfindahl sales high	−0.269	0.000	−14.0	0.000	0.023	0.077	0.0	4.9	0.310	0.000	6.6	0.000	0.187	0.428	3.9	0.0
Herfindahl total assets low	−0.229	0.000	−24.4	0.000			0.0	5.2	0.348	0.000	15.5	0.000			5.3	0.4
Herfindahl total assets high	−0.239	0.000	−13.2	0.000	0.422	0.525	0.0	4.6	0.260	0.000	6.1	0.000	0.053	0.146	4.4	0.0
Traded goods	−0.229	0.000	−19.7	0.000			0.0	4.2	0.364	0.000	13.3	0.000			5.6	0.2
Non-traded goods	−0.232	0.000	−20.5	0.000	0.340	0.839	0.0	6.2	0.315	0.000	10.8	0.000	0.072	0.156	4.5	0.4

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, $R_{\mathrm{FX}jt}$ is the percentage change of a trade-weighted exchange rate index for country j, and $D_{\mathrm{Euro}t}$ is a dummy variable that takes the value 1 after 1/1/1998 and 0 otherwise. Results are reported for different subsamples of multinationals defined by firm characteristics (Panel A), region (Panel B), and industry (Panel C). "High" and "low" refer to firms above and below the median, respectively. 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 is reported in the next column. The table reports further the probability of a two-sided Wilcoxon rank sum test of equal coefficients across samples ("Wilcox"), as well as p-values of a Chi-squared test ('Chi') of equal medians. The columns '% pos.' and '% neg.' report the percentage of significant positive and negative coefficients, respectively. Total sales, foreign sales and foreign Europe sales are based on data reported in Table 1. Firms are classified into strong and weak EMU currencies using the definition in Bris et al. (2003) (footnote 6). The Herfindahl index value is computed on the basis of total sales or total assets by global industry group as classified by Datastream (Level 6 classification). Tradeable versus non-tradeable goods classification is based on Griffin and Karolyi (1998) as applied to the Level 6 Datastream industry classifications.

is significantly larger for firms with above-median sales (−0.305) than for those with little sales (−0.086). While differences in the percentage of total foreign sales do not appear to be important for the extent of the decline in market beta, firms with a higher fraction of foreign sales in Europe have (marginally) smaller estimates of β_{Euro}.

Also in line with the previous findings is the impact of the Euro on the incremental foreign exchange rate exposures. In addition to the observed pattern of net reduction in foreign exchange rate exposures, some interesting cross-sectional results obtain. For both, positive and negative exposures, the *absolute* level of exposure is higher for multinationals with below-median sales. At the same time, the exposure (of either sign) is larger for multinationals that also have a higher fraction of total foreign sales or of a higher fraction of foreign sales in Europe. All these findings are highly significant by the Wilcoxon and Chi-squared test and appear in line with economic intuition. Furthermore, we do not only observe that changes and levels of exposure have the opposite sign, but that cross-sectional differences in exposure translate into corresponding differences in changes in exposure. To illustrate, firms with below-median sales, a higher fraction of total foreign sales and foreign sales in Europe have not only larger foreign exchange rate exposures of either sign before the Euro, but also show significantly larger declines in exposure toward zero. These tests are again usually significant, except for changes in positive exposures across firms with above- and below-median fraction of total foreign sales, i.e. −0.177 is not significantly larger than −0.159.

Panel B of Table 7 investigates results of regional subsamples of multinationals. The results show that multinationals in the Euro area have significantly larger betas (0.600) than those in Non-Euro Europe (0.475), but they are smaller compared to betas of multinationals outside of Europe (0.950). In contrast, when we split the sample into multinationals in strong EMU countries (Austria, Belgium, France, Germany, Greece, Luxembourg, and the Netherlands) and weak EMU countries (Spain, Finland, Ireland, Italy, and Portugal), there are no significant differences in the betas.[15] The changes in market betas are significantly different across regions and in line with the differences in the pre-Euro levels of betas. Multinationals with smaller (higher) betas in Non-Euro Europe (outside Europe) have significantly smaller (larger) reductions of market betas compared to firms in the Euro area. In contrast, there are no significant differences between strong and weak EMU countries.

In focusing on the foreign exchange rate exposures and their changes, the previous finding of a net reduction is apparent as well.[16] The evidence suggests here that multinationals in the Euro area have significantly larger positive (negative) exposures of 0.283 (−0.343) than similar firms in Non-Euro Europe with 0.214 (−0.212) and outside of Europe with 0.184 (−0.150). Moreover, firms in strong EMU countries have significantly larger negative exposures (−0.359) compared to weak EMU countries (−0.295). The pattern in the changes of exposures corresponds largely to that of the levels before the Euro. Interestingly, firms in strong EMU countries have smaller changes in negative exposures (0.315 versus 0.513) despite the fact that they show larger levels of exposures (−0.359 versus −0.295).

Finally, firms are split by various industry characteristics in Panel C of Table 7. We measure the degree of competition in an industry with Herfindahl indices based on total sales or total

[15] Our definition of "strong" and "weak" EMU currencies is based on that of Bris et al. (2003) (p. 9). They identify as weak those that "suffered a currency crisis in the years before the introduction of the euro" and specifically allude to those that were targets of speculative attacks on the European exchange rate mechanism (ERM).

[16] Note that the two median coefficients of changes in positive foreign exchange rate exposures that show a positive estimate, i.e. that have the "wrong" sign, are both not significant, and both subsamples show higher percentages of significant negative coefficients.

assets by industry group, and also split firms into traded goods and non-traded goods industries based on the classification in Griffin and Karolyi (1998).[17] The main results of this analysis are that firms in more competitive industries (those with lower Herfindahl values) have significantly larger reductions in market betas (−0.222 versus −0.148, and −0.210 versus −0.177 for Herfindahl indices based on sales and assets, respectively). At the same time, there is some support for the idea that firms in traded-goods industries should be affected more strongly by the introduction of the Euro, as their reduction in market betas of −0.205 is significantly larger than for firms in non-traded goods industries (−0.191). Both of these results are useful support of the findings in Bodnar et al. (2002) that empirically-estimated exchange rate exposures from stock return regressions can be small relative to that which would be expected from a structural model of a firm's pass-through decision, which is related to the competitiveness of its industry.

The industry samples also show significant differences in the level of foreign exchange rate exposure. In particular, firms in industries with low values of the sales-based Herfindahl indices show significantly smaller exposures both positive (0.201 versus 0.271) and negative (−0.222 versus −0.269). The results for Herfindahl indices computed on assets are similar, but less significant. Firms with positive exposures (which are likely to be net-exporting firms) show larger exposures when they are in traded-goods industries, but the difference is too small to be significant. There are surprisingly small differences in the changes in exposure after the introduction of the Euro. For positive exposures, the coefficients appear to be larger for firms with high Herfindahl values and in traded-goods industries, but the tests of cross-sectional differences fail to show significance. For negative exposures, the changes are larger for firms in highly competitive industries, and the difference in coefficients for firms with low and high values of the Herfindahl index based on assets (0.348 versus 0.260) is significant (p-value of Wilcoxon test of 0.053). Similarly, firms in traded goods industries have larger changes of negative exposures compared to firms in non-traded industries (0.364 versus 0.315 with Wilcoxon p-value of 0.072).

In summary, these tests suggest that our results are robust to a broader set of multinational firms. Moreover, economic exposure determinants based on firm characteristics, i.e. firm size as measured by sales, and the extent of foreign business, as measured by the degree of total foreign sales and foreign sales in Europe, can be sensibly related to the documented effects on market and foreign exchange rate betas. By the same token, there are important cross-sectional differences across firms based on geographic location, particularly relative to the Euro area and with regards to the strength of the local currency prior to adopting the Euro, as well as industry characteristics (competition, traded-goods industries).

4.6. Additional robustness checks

We also conduct a number of robustness tests related to methodology, data, and analysis. First, we argued that market participants anticipated the introduction of the Euro, so that its effect should be reflected in stock prices already in 1998. Nevertheless, we also replicate all tests in the

[17] The Level 6 sector classifications in Datastream and the definitions used in Griffin and Karolyi (1998) are not perfectly consistent, though very close. An appendix detailing the exact assignments of sectors to tradeable and nontradeable goods is available from the authors upon request. Summary statistics on Herfindahl index values computed on the basis of total sales or total assets (both averaged across 1990 to 2001) by industry group are also available upon request.

paper using January 1, 1999 as the event date, excluding the year 1998 as a transition period, or limiting the sample period to the years 1993–1996 (pre-Euro) and 1999–2001 (post-Euro). The results and inferences are largely robust to these alternative specifications, suggesting that the economic effects we observed are not simply transitional in nature.

Another concern might be that 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 4 and 5 using a global market index (the Datastream World Market Index in local currency) instead of the respective domestic market indexes by country. The average global market betas in the pre-Euro period are significantly smaller than local market betas across all regions, especially in Non-Euro Europe, so we see smaller declines in global market risk exposures following the Euro launch. However, the foreign exchange risk exposures and their changes are just as large. We also incorporate a two-index model into our analysis with both local and global market betas concurrently. The resulting global market risk exposures are significantly smaller yet again and the fraction of significant changes declines dramatically. Our primary inferences for local market exposures and their changes in these specifications do not change.[18]

Finally, we are concerned that our results may be sensitive to the industry classification employed to match multinational firms with the industry control sample. The industry control firms are matched at the highest degree of detail on sector information provided by Datastream (Level 6). In order to assess the robustness of our results, we re-estimate our tests using fewer industry sectors (Level 4), but the results of all specifications are very similar.

5. 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 3220 corporations in 20 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 stock market volatility of many countries and stock return variances of nonfinancial firms increase during the sample period. There is some evidence, though weak, of lower increases for firms with foreign sales or assets in Europe relative to samples of control firms. Specifically, the increase in stock return volatility is smaller in the Euro area compared to other regions, indicating that firms in the Euro zone benefited most from the elimination of exchange rate risk in Europe. The second and most important finding in our paper is that the introduction of the Euro leads to lower market risk exposures for multinational 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 multinational firms relative to firms without foreign business in Europe in the same industry or with similar firm size.

Consistent with prior research (e.g. Jorion, 1990; Griffin and Stulz, 2001), our third stage of analysis shows that few sample firms show significant levels of incremental foreign exchange rate

[18] We are grateful to Francesca Carrieri and Vihang Errunza for this suggestion. Details of all of these supplementary experiments are available from the authors upon request.

exposure. However, the Euro does have an impact on these exposures as they decline in *absolute* terms after the launch of the common currency, which implies that the Euro entailed a net reduction in foreign exchange rate risk exposures. Thus, consistent with Bartov et al. (1996), we are able to link changes in currency regimes, such as the transition between floating and fixed exchange rates, to foreign exchange rate exposures. Finally, in line with economic theory (Bodnar et al., 2002), the changes of market and foreign exchange rate betas of multinationals are shown to be a function of firm characteristics (sales, the percentage of foreign sales in general and in Europe in particular), regional factors (geography, strength of currency), and industry characteristics (competition, traded goods). The finding of reductions in market betas suggests that nonfinancial firms should benefit from increased potential to carry business risk or debt, reduced cost of capital and should, thus, experience higher firm valuations. We know that changes in market risk could, in principle, also result from changes in financial leverage, but the empirical evidence does not support this alternative explanation.

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 4 years following the 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 US 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 et al. (2005) 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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