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“Exchange Rate Risk” within the European Monetary Union? Analyzing the Exchange Rate Exposure of German Firms*

Oliver Entrop†, Matthias F. Merkel‡

Abstract

In this paper we show that inflation differentials among the countries in the European Monetary Union (EMU) are an economically significant risk to German firms, which make up the largest economy in the EMU. This risk can be interpreted as real “exchange rate exposure” resulting from trade within the euro area. Actually, we find that this EMU exposure is nearly as high as the standard exchange rate exposure caused by trade with non-EMU countries. Moreover, our analysis shows that many of the conventional factors that drive firm-specific exchange rate risk, such as size, debt ratio, asset turnover and foreign business activity, also determine EMU exposure in an economically meaningful way. However, EMU exposure challenges firms’ risk management, particularly as it cannot be reduced by standard financial hedging instruments, such as currency derivatives.

Keywords: Currency risk, inflation differentials, single-currency area

JEL classification: F23, F31, G15

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1 Introduction

Many companies face risk due to changes in exchange rates as they have cash flows from abroad due to international trade or foreign operations, or assets denominated in foreign currency.[1] One of the central reasons for the introduction of the European Monetary Union (EMU) was to eliminate exchange rate risk and to boost trade by enabling the companies in the euro area to operate free from the uncertainties of exchange rate movements (Dominguez and Tesar, 2006). However, a single currency like the euro in the EMU only eliminates nominal exchange rate risk, while inflation differentials may still exist (and may vary over time), for example due to different states in the business cycle or not fully integrated goods and labor markets. In fact, there are significant inflation differentials in the euro area and – to a lesser extent – even in the U.S. (e.g., Altissimo et al., 2005, Angeloni and Ehrmann, 2007).

Depending on their direction, inflation differentials can positively or negatively affect the competitiveness of an exporting or importing firm on both the foreign and home markets and, thus, its cash flows and profits. This is because revenues and costs are generated in areas with differing levels of inflation.[2] Consequently, cash flows and profits should be sensitive to changes in inflation differentials, i.e. such changes pose a risk to firms that can be interpreted as real "exchange rate risk" resulting from trade within the single currency area EMU.[3] It may be of

[1] It should be noted that even companies that do no international business may be exposed to currency risk as they compete in their home markets with foreign companies, that may profit from changes in bilateral exchange rates, which would therefore affect the competitiveness and the profits of the domestic company (Aggarwal and Harper, 2010).

[2] For example, in recent years, German exporting firms on average benefited *ceteris paribus* from the inflation differentials in the EMU as Germany has had the lowest inflation rates.

[3] It should be noted that this real "exchange rate risk" resulting from trade in the euro area is not the standard real exchange rate risk when two different currency are involved. The risk arising from inflation differentials is simply the risk of a change in a real exchange rate if the standard definition is applied to a single currency area where the

particular importance for the firms, as easily implementable standard tools that can be used to reduce nominal exchange rate risk, such as foreign currency derivatives or foreign currency-denominated debt, are not viable options for mitigating such risk.

In this paper we investigate the existence of such real "exchange rate risk" that results from trade within the EMU (referred to as EMU exposure) and their relevance for German firms over the time period 2004 to 2013. Additionally, we compare the EMU exposures to exposures to exchange rate risk arising from business outside the euro area, i.e. the rest-of-world (ROW), which we call ROW exposure. Moreover, we analyze firm-specific determinants of these exposures to identify possible drivers of the respective risk. We focus on German firms as Germany is the largest economy in the EMU, with huge trade activities inside and outside the euro area, and is a major worldwide exporter. This makes Germany very suitable for our analysis.

To the best of our knowledge this paper is the first to analyze EMU exposure or – more generally – to analyze inflation-based "exchange rate exposure" in a single currency area. In contrast a large body of empirical work has analyzed firms' exchange rate exposure in its classical sense and respective determinants in a single- or multi-country context.[4] These studies estimate a firm's exchange rate exposure based on how sensitive its stock returns are to changes in a bilateral exchange rate or a multilateral trade-weighted foreign exchange rate index in a (multi-) factor model. Following this approach, we extend the Fama-French three-factor model using a trade-weighted exchange rate index. Adopting the standard methodology of the ECB and

nominal exchange rate is fixed at one; this will be explained in more detail in the following. Capturing this risk in the exchange rate risk framework also allows us to directly compare results for risk resulting from trade inside the euro area with the results from trade with countries outside the euro area.

[4] These studies include, among others, Jorion (1990), Bartov and Bodnar (1994), Choi and Prasad (1995), Chow et al. (1997), He and Ng (1998), Brunner et al. (2000), Allayannis and Ofek (2001), Dominguez and Tesar (2001), Bodnar and Wong (2003), Bartram (2004), Pritamani et al. (2004), Doidge et al. (2006), Dominguez and Tesar (2006), Aggarwal and Harper (2010), Hutson and Laing (2014).

the BIS (see Turner and Van't dack, 1993; Klau and Fung, 2006; Schmitz et al., 2012), we construct appropriate indices as trade-weighted means of exchange rates adjusted by corresponding consumer prices indices (real exchange rate indices). However, for the EMU exchange rate index we only consider trade within the euro area while the ROW exchange rate index is based on trade outside this area. Consequently, the EMU exchange rate index is solely based on inflation differentials vis-à-vis the EMU trading partners, because the bilateral nominal exchange rates within the EMU are constant and equal one. Moreover, to best capture the different trade patterns of different industry sectors we construct – in contrast to earlier studies[5] – our indices industry-specifically, based on each industry sector's trade activities. So that our results are comparable with other papers on exchange rate exposure, we also estimate exposures to the overall exchange rate risk that is caused by trade inside and outside the euro area (Overall exposure). Accordingly, the Overall exchange rate indices include all trade activities of the respective industries.

Estimating yearly exposures for each year of the observation period allows us to run analyses of resulting exposures in both the cross-sectional and time-series dimension. Not surprisingly, our results show that German firms are generally exposed to standard exchange rate risk, producing sizeable ROW and Overall exposures. As the exposures are estimated from stock returns they represent post-hedging exposures, i.e. after operational and financial hedging (including foreign

[5] An exception is Dominguez and Tesar (2006) who consider industry-specific indices. However, their indices only capture the top (top three) trading partners of a particular industry and they do not match imports and exports, but create import- and export-based indices.

exchange derivatives and foreign currency-denominated debt), and the possibility of passing-through the effects of exchange rate movements to customers.[6]

Most importantly for our study, we find significant EMU exposures. Our results show that German firms face economically relevant "exchange rate risk" within the euro area caused by inflation differentials vis-à-vis the EMU trading partners. Indeed, average EMU exposure is nearly as high as average ROW exposure.

These findings have important implications for the risk management of firms as this kind of risk is difficult to hedge. Normative theory implies that hedging is beneficial to firm value, for example via a reduction in expected financial distress costs (Smith and Stulz, 1985), by increasing a firm's debt and tax shield capacity (Leland, 1998) or by reducing the need for costly external financing (Froot et al., 1993).[7] With regard to inflation differentials, while firms may still be able to pass-through increased or decreased costs to their customers that occur due to different inflation rates or to change the location of costs by relocating production facilities, they cannot use the spectrum of financial products that are the first choice for reducing standard exchange rate exposure. Accordingly, firms can neither use currency derivatives, as these are generally hedges against nominal exposure, nor raise money in "foreign" currencies, as the nominal value of the euro is identical in all EMU countries. Consequently, our results highlight

[6] Firms can utilize financial hedges by using financial products, such as foreign currency derivatives or foreign currency denominated debt, to immunize their cash flows against exchange rates movements. Another option is to make use of operational hedges, for example by relocating production facilities abroad to change the currency of costs. Additionally, firms can try to pass-through to their customers the changed input costs that occur due to exchange rate movements. Such risk mitigation activities significantly reduce exposure as shown by Allayannis and Ofek (2001) and Bartram et al. (2010), who report that financial hedging reduces exposure by about 40%, while operational hedging and pass-through by only 10-15% each. Accordingly, the observed level of foreign exchange exposures in empirical studies is generally far smaller than the exposure predicted by theoretical models (see, e.g., Bodnar et al., 2002; Bartram et al., 2010).

[7] This is supported by empirical evidence by, amongst others, Allayannis and Weston (2001), Mackay and Moeller (2007), Bartram et al. (2011), Allayannis et al. (2012).

the challenges for firms' risk management policy in this context in protecting themselves against exchange rate risk arising from inflation differentials. Unfortunately, the market for macro derivatives such as inflation swaps, which would make the risk from inflation differentials tradable and hedgeable, is still poorly developed.

On looking more closely at the estimated exposures, we find large cross-sectional variation but also a certain persistence at the firm level over time. In fact, more than half of the very large EMU exposures are caused by 20% of the firms. This suggests that they result from firms' business models and individual characteristics. Therefore, we link EMU exposures (as well as ROW and Overall exposures) to a broad set of firm-specific characteristics to identify their determinants.[8] We apply standard panel regressions to capture the average relationships, logistic regressions to identify the drivers of high exposures, and unconditional quantile regressions according to Firpo et al. (2009) to analyze the effects of the considered characteristics on quantiles of the exposure distribution.

Interestingly, the key effects are similar in all these analyses, implying that the economic relationships are quite robust. For the EMU exposure we find significant links with firm size, asset turnover and leverage. In particular, greater firm size reduces EMU exposure, suggesting that larger firms achieve higher risk reduction. This is plausible as larger firms are more likely to show higher product, client and country diversification in the EMU and are also more likely to better balance revenues and costs across countries because of more non-German production facilities – as analogously argued by Lang and Stulz (1994) and Aggarwal and Harper (2010) in

[8] Both theoretical literature and empirical research has identified a number of determinants of standard exchange rate exposure. Typically, foreign (business) activity, firm size, leverage and currency derivative usage significantly affect exchange rate exposure (e.g., Jorion, 1990; Choi and Prasad, 1995; He and Ng, 1998; Allayannis and Ofek, 2001; Bodnar and Wong, 2003; Doidge et al., 2006; Dominguez and Tesar, 2006; Aggarwal and Harper, 2010; Bartram et al., 2010; Hutson and Laing, 2014).

the context of firm size-effects. Likewise, higher asset turnover significantly reduces exposure, indicating that efficient asset management shields firms against changes in prices due to inflation differentials within the EMU. Lower levels of debt are associated with lower exposure and simply illustrates that less indebtedness makes a firm's equity less susceptible to risk, including that from inflation differentials. While these variables show symmetric effects on exposure, i.e. both positive exposures (net importers) and negative exposures (net exporters) get closer to zero (and the probability of showing a large positive or large negative exposure is reduced), the effects of foreign sales and foreign purchases (each normalized to total sales) are asymmetric. For net exporters an increase in foreign sales is associated with an increase in exposure, as their already existing net export positions are becoming even higher. In contrast, for net importers, an increase in the foreign sales ratio makes the exposure less negative since the net import position is becoming smaller. For foreign purchases effects are the other way round. However, while these effects are stable they are not always statistically significant.

When analyzing the determinants of ROW and Overall exposures we find the same determinants as for EMU exposure. In addition, we also observe that foreign currency derivative usage decreases exposure, which is in line with the common hypothesis that firms use derivatives for hedging purposes. Plausibly, this does not affect EMU exposure. Finally, we find some evidence that increases in the current asset ratio are associated with increases in exchange rate exposure, indicating that a higher portion of current assets leads to higher exposure as these assets, like raw materials and inventories, are more prone to price changes (see Aggarwal and Harper, 2010).

Summarizing our key results, “exchange rate risk” within the EMU – which is based on inflation differentials among the countries – is an important risk to German firms, has plausible firm-specific determinates and is hard to manage. Of course, inflation differentials do not only exist between EMU countries but also between the countries inside and outside the euro area. To check the economic robustness of our results on the relevance of inflation differentials, we further split the ROW exchange rate index and construct two (again industry-specific) index alterations, one including the trade-weighted nominal exchange rates based on Germany’s trade with the ROW countries (ROW Nominal exchange rate index) and one including only the trade-weighted inflation differentials between Germany and the ROW countries (ROW Inflation differentials exchange rate index). The latter is the pendant to the EMU exchange rate index. We rerun our analyses from above and achieve similar results for the ROW-Infl-diff exposures compared to the EMU exposures in terms of relevance and determinants. Accordingly, these findings corroborate the identified relationships between firm characteristics and exposures to risk from different inflation rates among countries.

The remainder of the paper is organized as follows. Section 2 describes our empirical strategy and methodology. Section 3 introduces our data, while Section 4 presents the empirical results. Section 5 reports a set of robustness tests. Finally, Section 6 concludes.

2 Empirical strategy and methodology

2.1 Estimating exposure

Utilizing the fact that the market value of a firm represents the present value of all future cash flows[9], Adler and Dumas (1984) estimate exchange rate exposure as the sensitivity of a firm's stock returns to changes in the exchange rate, obtained from a simple linear regression. Jorion (1990) adds a market index as an independent variable to control for general market influences:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \gamma_i R_{FX,t} + \varepsilon_{i,t} , \quad (1)$$

where $R_{i,t}$ is the total excess return of firm *i* over period *t* and $R_{m,t}$ is the total excess return of the market index *m* over period *t*. $R_{FX,t}$ is the percentage change of an exchange rate or exchange rate index over period *t*. The resulting coefficients γ_i on the exchange rate variable represent the exchange rate exposure.[10] To avoid potential biases due to firm size and firm value, we alternate the Jorion-model and include the Fama and French (1992, 1993) factors (as also done by Aggarwal and Harper, 2010; Chang et al., 2013):

$$R_{i,t} = \alpha_i + \beta_{i,m} R_{m,t} + \beta_{i,SMB} R_{SMB,t} + \beta_{i,HML} R_{HML,t} + \gamma_i R_{FX,t} + \varepsilon_{i,t} , \quad (2)$$

[9] Early literature discussing exchange rate exposure includes Shapiro (1975), Aggarwal (1976), Hodder (1982) Heckman (1985), Flood and Lessard (1986), and Levi (1994) and focuses on the impact of exchange rates on firms' cash flows.

[10] It is worth to note that the exposure coefficient obtained from the two-factor model "only" represents the residual exchange rate exposure as the implementation of the market return controls for the market portfolio's own exchange rate exposure (see Bodnar and Wong, 2003, for detailed discussion).

where $R_{SMB,t}$ is the small-minus-big factor, i.e. the return difference between small and large stocks in period t, and $R_{HML,t}$ is the high-minus-low factor, i.e. the return difference between value and growth stocks in period *t*. Standard errors are corrected according to Newey and West (1987).

We estimate exposures for each firm in our sample for each year of the observation period from weekly returns. In line with most of the current literature, we use the returns of a multilateral trade-weighted foreign exchange rate index for $R_{FX,t}$ (see, e.g., Dominguez and Tesar, 2006; Bartram et al., 2010).[11] Because existing trade-weighted foreign exchange rate indices usually involve countries from both inside and outside the euro area, we construct our own trade-weighted EMU exchange rate index. Following the methodology of the ECB, this real exchange rate index (RERI) – that is used to derive the exchange rate variable $R_{FX,t}$ – is calculated as the weighted geometric average of the bilateral inflation-adjusted exchange rates (see Schmitz et al., 2012):

$$RERI_t = \prod_{i=1}^{N} \left(\frac{e_{i,t} \times \frac{CPI_{Ger,t}}{CPI_{i,t}}}{e_{i,0} \times \frac{CPI_{Ger,0}}{CPI_{i,0}}} \right)^{w_{i,t}} \quad (3)$$

$$\text{with } \sum_{i=1}^{N} w_{i,t} = 1, \;\; w_{i,t} \geq 0, \quad (4)$$

where *N* is the number of trading partners included in the index calculation. $e_{i,t}$ is the nominal exchange rate of the currency of trading-partner-country *i* to the euro at time *t*, while $e_{i,0}$ is the corresponding exchange rate at the end of the base year 2002. The exchange rates are indirect

[11] In Section 5 we perform several robustness tests for different model specifications.

quotes. $CPI_{Ger,t}$ ($CPI_{Ger,0}$) and $CPI_{i,t}$ ($CPI_{i,0}$) are the levels of the consumer price indices of Germany and trading-partner-country i at time t (at the end of the base year 2002), respectively. $w_{i,t}$ is the trade weight assigned to the currency of trading partner i at time t and includes direct bilateral trade and third-market competition (based on trade data obtained from the OECD). Appendix A shows the algebra of the weight calculation in detail. We use time-varying weights to reflect the changing trade patterns and chain-link the index whenever trade-weights change.[12]

Our EMU exchange rate index includes 11 to 16 countries (as five countries have just entered the EMU during the observation period) and trade within the EMU counts for approximately 36.4% of Germany's total foreign trade. Obviously, the EMU exchange rate index only involves trade-weighted inflation differentials between Germany and the EMU countries as these countries share a single currency and the nominal exchange rate is one.

Besides the EMU exchange rate index, we additionally construct a ROW exchange rate index that includes solely the countries from the ROW and an Overall exchange rate index that includes countries from both the EMU and ROW. In contrast to the EMU exchange rate index, these indices entail both inflation differentials between the countries as well as nominal exchange rates. Our Overall exchange rate index contains 55 countries covering approximately 92.7% of Germany's total foreign trade.[13]

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[12] Chain-linking the index avoids changes in the exchange rate index that are solely due to changes in the weight patterns. See Alsterlind (2006) for details.

[13] Appendix B presents a list of the countries included in the index calculations. Generally, we include the same countries as the BIS for calculating their broad exchange rate index (see Klau and Fung, 2006). However, their index includes 59 countries, but trade data is not available for four countries (Algeria, Peru, United Arab Emirates and Venezuela). Hence our Overall exchange rate index contains only 55 countries. Moreover, information on CPI is not available for some economies in our sample. Therefore, we only adjust those few countries with information on CPI, while we continue to use nominal exchange rates for the remaining countries. However, the weights of those countries only represent 4.4% of the weights of the Overall exchange rate index.

Figure 1 shows the development of the EMU and ROW exchange rate indices and the corresponding relative monthly changes over time. As expected, the ROW exchange rate index shows partly strong fluctuations, but also the EMU exchange rate index has visible movements and both positive and negative relative changes. The average depreciation of the EMU exchange rate index reflects that the German prices have declined relative to the prices in the other EMU countries and that Germany has had the lowest inflation rates among the countries in the euro area in our observation period.

[Figure 1 about here]

The indices in Figure 1 are based on economy-wide total trade, but do not capture different trade activities among the firms. Therefore, we construct industry-specific exchange rate indices based on each industry sector's foreign trade to capture different trade patterns.[14] In particular, we construct trade-weighted EMU, ROW and Overall exchange rate indices for 17 industry sectors.[15] Exemplarily, Figure 2 demonstrates the development of the industry-specific trade-weighted Overall exchange rate indices and their corresponding relative monthly changes over time. The different indices are highly correlated, but partly vary substantially, which highlights the relevance of using different measures among different industries.

[Figure 2 about here]

[14] Certainly, the calculation of firm-specific exchange rate indices would be best, but the necessary information on geographic trade is not available at firm-level.

[15] We group firms into industry segments as suggested by the OECD (see Section 3 for details). The OECD provides trade information at industry-level for the years 2000, 2005 and 2008-2011. For these years we calculate each trading partner's export and import share. For the years in which trade information is not available, we simply interpolate these values. For the years 2012 and 2013, we carry forward the shares calculated for the year 2011.

2.2 Explaining exposure

After having estimated the yearly exposures of the firms, we relate them to firm-specific characteristics. Following prior studies we use a broad set of variables (see, e.g., Allayannis and Ofek, 2001; Aggarwal and Harper, 2010; Hutson and Laing, 2014). We basically apply three regression designs. First, we use standard panel regressions to analyze the average relationship. Next, we apply logistic regressions to identify the drivers of high exposures, i.e. those firms that are very prone to the considered risks. Finally, we apply unconditional quantile regressions to analyze whether the link between exposure and the firm characteristics depends on the size of the exposure.

In more detail, we first estimate the following regression:

$$\hat{\gamma}_{i,T} = \alpha + \sum_{n=1}^{N} \beta_n \; FirmCh_{n,i,T} + \varepsilon_{i,T} \, , \qquad (5)$$

where $\hat{\gamma}_{i,T}$ is the estimated exposure of firm i for year T and $FirmCh_{n,i,T}$ is the specific firm characteristic n of firm i for year T (which will be defined later). We set industry and year fixed-effects and calculate cluster-robust standard errors.

Second, we apply logistic regression to more deeply investigate the determinants of high exposures. To do so we set two binary variables D_q that equal 1 if the yearly exposure is very low (below the 10% quantile of the exposure distribution, q = 10%) or very high (above the 90% quantile of the exposure distribution, q = 90%), respectively, and analyze the probability that a yearly exposure lies in the high (low) quantile of the exposure distribution of that year. We run the following logistic regression:

$$logit\left(P\left(D_{q,i,T} = 1\right)\right) = \alpha + \sum_{n=1}^{N} \beta_n \ FirmCh_{n,i,T} , \quad (6)$$

where the dependent variables $D_{q,i,T}$ are the dummy variables mentioned above. We also add industry and year fixed-effects. As the standard ML-estimator may be biased in this case, we use the conditional estimator (Chamberlain, 1980) and calculate cluster-robust standard errors.

Finally, we apply unconditional quantile regression developed by Firpo et al. (2009) to Equation (5).[16] This approach shows how an unconditional quantile of the pooled exposure distribution is related to the explanatory variables. The estimated coefficients of the variables on the right hand side may differ in sign, magnitude and significance between the unconditional quantiles, which would show that the explanatory variables of interest have different impacts throughout the outcome distribution. Accordingly, this approach also allows us to analyze in more depth the tails of the exposure distribution where high exposures are located. Again, we set industry and year fixed-effects and calculate robust standard errors bootstrapped from 1,000 replications.

3 Sample selection and data

We start our sample with German firms that have been listed in the Prime or General Standard market segments during the years 2004 and 2013.[17] To qualify for our sample a firm must have

[16] We are deeply grateful to Nicole Fortin for providing the STATA ado-file on her homepage.

[17] We chose to start in 2004 because German law requires companies listed in the Prime and General Standard to prepare their annual reports for the years after 2004 in accordance with the International Financial Accounting Standards (IFRS). Since most firms in our sample had already started to use IFRS in 2004 or show adjusted results

had both total assets and total sales of more than 50 million euros at least once during this period. We exclude financial firms (SIC 60-67) as they are heavily regulated. Our final sample contains 378 firms. We estimate yearly exposures for each firm-year between 2004 and 2013. However, since some of the firms entered or left the Prime or General Standard during the observation period, we only include those years in which the firm was listed in one of the indices mentioned above to provide uniform accounting standards among the firm observations. Moreover, we exclude firm-years in which we do not have stock return data for a sufficient period of time. In particular, a firm must have at least 20 weekly consecutive observations in the considered year. Furthermore, we eliminate firm-years with stale prices for more than 5 (weekly) observations. We end up with an unbalanced panel of 2,868 firm-years that we group into 17 industry sectors. Table 1 presents the industry breakdown as suggested by the OECD including the corresponding SIC codes.

[Table 1 about here]

We obtain firms' equity total returns of these firms from Thomson Reuters Datastream. As risk-free rate we use the EUREPO rates provided by the European Money Market Institute. The total returns of the CDAX, a composite index of all stocks traded on the Frankfurt Stock Exchange listed in the Prime or General Standard, is used as the market index as shown in Equation (2) and is also obtained from Thomson Reuters Datastream. Fama-French factors for the German market are provided by the Humboldt University in Berlin.[18] For the exchange rate

for 2004 in their annual reports of 2005, our analysis starts in 2004 (excluding the few observations in 2004 which do not correspond to IFRS) so as to have homogenous accounting standards.

[18] We are deeply grateful to Richard Stehle for providing the Fama-French factors on his homepage.

index calculations, we obtain bilateral exchange rates from Thomson Reuters Datastream, while industry-specific trade data and CPIs come from the OECD.

Finally, we obtain data on firm-specific characteristics from Thomson Reuters Worldscope and the OECD, respectively, and hand-collect information on foreign currency derivative usage, foreign sales, and expenditures for research and development from the annual reports of the companies. Table 2 gives a brief overview of selected variables of our sample.[19]

[Table 2 about here]

Panel A shows that the average weekly total return of the CDAX is 0.0018 and that the firms' average weekly total return is 0.0028. As the CDAX is a value-weighted index and thus dominated by large firms, whereas the reported average firm return represents the equally weighted mean over the sample, these returns cannot be compared directly with one another. However, they illustrate that smaller firms tend to perform better than larger firms. Moreover, firm returns are more widely dispersed than market returns, as indicated by the higher volatility and the 90% and 10%quantiles, which is plausible as the CDAX is diversified. Panel B presents summary statistics of some key firm characteristics. Measured by total sales, total assets and firm market value, our sample includes both small and large companies. The medians are much smaller, implying that we have some very large firms in our sample. Moreover, more than 50% of the average firm-year's total sales is earned on the foreign market (outside Germany), which demonstrates the export activity of the German economy.

[19] All variables are discussed in detail in Section 4.

4 Empirical Results

4.1 The extent of exposure

Using the extended Fama-French model as presented in Equation (2), we estimate yearly exposures using weekly returns with particular trade-weighted industry-specific exchange rate indices. We use standardized exchange rate index returns to make the estimated exposures comparable. Table 3 presents statistics of the estimated exposures. Columns (1), (2), and (3) include exposure to EMU, ROW and Overall exchange rate risk, respectively. Columns (4) and (5) also present EMU and ROW exposures, but the exposures are estimated jointly in one regression – by including both the EMU and the ROW exchange rate index in the model as presented in Equation (2), rather than estimating them separately.

[Table 3 about here]

Average EMU exposure is -0.039. Though this level is quite low, it gives a first indication that EMU "exchange rate risk" exists for German firms. This becomes even clearer when we weigh the estimated exposures by firm size (here proxied by total assets). Average value-weighted EMU exposure is -0.249 and accordingly significantly larger than the equally weighted equivalent. In addition, this finding provides a first indication that firm size may be related to exposure.

Moreover, exposures are widely dispersed as indicated by the high standard deviation (0.993) and the 90% and 10% quantiles. These parameters additionally show that exposures may differ in their direction. As the exchange rate indices utilized to measure exposure are based on indirect quotes, an increase in the EMU exchange rate index means that the German prices have increased relative to the prices in the other EMU countries. This makes the goods of German firms more expensive in other countries relative to local goods and hence harms net exporting firms. Accordingly, an increase in the index should reduce the value of net exporting firms so that the stock returns of these firms should be negatively related to changes in the exchange rate index.[20] Thus, one would expect negative exposures for net exporting firms to the EMU. On the other hand, net importers could expect to benefit from an increase in the index as the costs for imported goods decrease relative to local goods. Thus similarly, an increase in the index should increase the value of net importing firms and the stock returns of these firms should be positively related to changes in the exchange rate index.[21] Hence, net importers should have positive exposures.[22]

The negative means and medians of EMU exposures mentioned above are in line with the stylized fact that German firms are predominantly net exporters. When investigating positive and negative exposures separately we observe sizeable amounts. In particular, the mean of positive exposures is 0.539 and the mean of negative exposures -0.569. The extent of exposures becomes even higher when we only consider exposures that are statistically significant at the 10% level

[20] Analogously, a decrease of the EMU exchange rate index – as was observable in recent years in the euro area due to the decline in German prices relative to the price of the other EMU countries (see also Figure 1) – benefits German net exporting firms. Hence, a decrease in the index should increase the value of net exporting firms so that also from this point of view the stock returns and the changes in the exchange rate index should be negatively linked.

[21] Conversely, a decrease of the index harms German net importing firms as their imports become more expensive relative to local goods. Hence, a decrease in the index should decrease their value; the relationship between the stock returns of net importers and changes in the exchange rate index remains positive.

[22] It is worth noting that an increase in the EMU exchange rate index may also have reverse effects. In this case foreign firms are able to serve the German market with cheaper products – as their prices have declined relative to the German prices – leading to increased competition for domestic companies on the home market, which may result in a decrease in the value of some firms, especially those that are predominately active on the domestic market as net-importers

where average positive exposure is 1.190 and average negative exposure -1.254.[23] Accordingly, our results show economically significant EMU exposures for the firms in our sample.

To make our results comparable to others studies on foreign exchange rate exposure we also estimate exposure to ROW and Overall exchange rate risk. The results for ROW exposures and Overall exposures are quite similar and on average negative. This finding is generally in line with our expectations and reflects the export orientation of German firms. The number of firm-years with statistically significant exposures at the 10% level is relatively small, but in line with findings from recent studies on exchange rate exposure, and results from the fact that we measure ex-post exposure as already discussed in Section 1.

As Columns (4) and (5) show, the results for EMU and ROW exposures are similar when estimating them jointly in one regression – by including both the EMU and the ROW exchange rate index in the model as presented in Equation (2), rather than estimating them separately in two separate regressions.

As we use standardized exchange rate index returns, we can directly compare the exposures to each other. Average EMU exposure is comparatively large – indeed more than half of the ROW exposure. This relation is even more striking when we look at positive and negative exposures separately, where average EMU exposure reaches almost the level of ROW exposure. On investigating this observation further we find that for approximately 40% of our firm-years EMU exposure is larger than ROW exposure (not tabulated). The most likely explanation for the comparatively large (ex post) EMU exposures is that risk from inflation differentials can hardly be hedged. Firms can neither use currency derivatives, as these are generally hedges against

[23] The level of firms with statistically significant exposures at the 10% level is 10-15%, which thus accords with many studies on standard exchange rate exposure (see Bartram et al., 2010, and the literature in Footnote 4).

nominal exchange rate risk, nor raise money denominated in foreign currencies. However, they still may have the possibility to relocate production facilities or pass-through increased costs to their customers; though the effects of these instruments are small compared to the effects of financial products that can be used to reduce standard exchange rate exposure (see Bartram et al., 2010). Summarized, our first results show the economic significance of EMU exposures for German firms and imply the importance of considering risk due to inflation differentials among the trading partners.

Next, we make use of the time-series dimension of our data. Figure 3 graphically illustrates the development of average exposures over the sample period. The mean exposures to all indices are close to zero and predominantly negative for any year of the observation period. However, we also observe that average exposures vary over time and find phases with high cross-sectional variation and extreme values in the tails of the distribution.

[Figure 3 about here]

To illustrate exposure at the level of single firms, Figure 4 presents the development of EMU and ROW exposures of 16 firms from different industry sectors. Both the size and the direction of exposure vary over time, whereby the magnitude depends on the firm. Some firms, like SIEMENS, have a fairly constant level of exposure that is centered around zero. Other firms have a consistently positive (like FRAPORT) or a consistently negative (like UMS INTERNATIONAL) EMU exposure. Still others, like CONTINENTAL or SUESS MICROTEC, show a striking variation of exposure over time.

[Figure 4 about here]

Next, we look at the persistence of high exposures. To do so, we define a dummy variable that equals 1 if the yearly exposure is high – i.e. below the 10% quantile or above the 90% quantile of the exposure distribution in the specific year, and zero otherwise for the remaining low exposures. Table 4 shows transition frequencies for each of the exposure specifications. About 83% of exposures that are low in one year are also low the following year. For existing high exposures, about 27% stay high the next year, while the remaining part changes to low exposures. However, in a further analysis – not tabulated – we find that high exposures are mainly concentrated among a small number of firms: about 20% of the firms in our sample account for approximately 55% of all high exposures. The accumulation of high exposures among a few firms suggests that the size of exposures is related to firms' business models and individual characteristics.

[Table 4 about here]

In the next sub-section, we therefore relate the estimated time-varying exposures to a number of firm-specific characteristics to identify their possible drivers.

4.2 The determinants of exposure

4.2.1 Firm characteristics as explanatory variables

Our explanatory variables include on- and off-balance sheet data as a means of best capturing firms' business and risk profiles. They are based on theoretical literature and empirical research on classical foreign exchange rate exposure. Generally, the expected effects of the explanatory variables are similar for EMU, ROW and Overall exposure.

We use two proxies for firms' activity on foreign markets. The *foreign sales ratio* is measured by foreign sales over total sales and the expected impact depends on the sign of the exposure. For a net exporting firm (negative exposure) that is harmed by an increase of the exchange rate index, an increase in foreign sales should amplify this situation even more as it would expose a higher fraction of total sales to risk. Consequently, exposure would become more negative, so that we expect a negative relationship. On the other hand, for a net importing firm (positive exposure) that is harmed by a decrease of the index, an increase in foreign sales would reduce the net import position. Accordingly, exposure should get smaller and we also assume a negative relationship.

In contrast, the effects of the ratio of *foreign purchases over total sales* should be diametrically opposed to the *foreign sales ratio*. However, data on foreign purchases is not available at firm-level, as companies are not required to report them. We therefore generate a proxy for foreign purchases. Using OECD's industry-level data on imports and exports for the 17 industry sectors, we estimate foreign purchases by multiplying the observed firm-specific foreign sales by the relation of imports to exports of the particular industry group.[24] For net exporters (negative exposures), an increase in foreign purchases should make exposure less negative as it leads to a smaller net export position. Hence, we expect a positive relationship. Conversely, for net importers (positive exposures) an increase in foreign purchases results in even more net

[24] Following Beber and Fabbri (2012), the underlying assumption of our calculations is that firms that have a certain share of an industry sector's total exports will very likely have a similar share of an industry sector's total imports.

imports and hence should make exposure even larger. Accordingly, we also expect a positive relationship.[25]

Besides the asymmetrical effects of foreign sales and foreign purchases, all other variables should have symmetrical effects. For the sake of clarity and brevity, we only describe the expected effects of the explanatory variables on positive exposures. Accordingly, the effects on negative exposures are the reverse.

The *debt ratio*, measured by total debt over total assets, is employed as a proxy for financial strength. We expect a positive relationship with exposure as the risk of equity is naturally higher for firms with higher debt ratios. Hence these firms should be more prone to additional risk.

Asset turnover, measured by total sales over total assets, represents the quality of a firm's asset management and can be seen as an indicator for the efficiency with which a firm deploys its assets to generate sales. A high asset turnover means that the firm is performing well since it generates many sales per unit assets. Consequently, it should be better protected against changes in prices. Therefore, we expect that increases in asset turnover will reduce exposure and thus produce a negative relationship (see, e.g., Aggarwal and Harper, 2010).

Likewise, the firm's *EBITDA margin* (EBITDA over total sales) should have a negative relationship with exposure. Since profitable firms should be able to better absorb changed costs, as they are more flexible in pricing goods, increases in the EBITDA margin should decrease exposure.

[25] It should be noted that our proxy for firms' foreign sales (and accordingly for foreign purchases) include sales to countries from both the EMU and ROW. The reader might wonder why we do not divide them according to the two areas. This is because the breakdown in the total number of foreign sales by geographic area is not available at firm-level for most of the companies in our sample.

We expect that *firm size*, here measured by the log of equity market value, has a negative impact on exposure. Larger firms may profit from risk reductions since they are more diversified regarding products and customers and more likely to better balance revenues and costs among countries due to more non-German production facilities. Furthermore, their risk management is usually more efficient as they have lower market participation costs and as they benefit from economies of scale (see, e.g., Nance et al., 1993; Dominguez and Tesar, 2006; Aggarwal and Harper, 2010).[26]

The *market-to-book ratio*, measured by the book value of debt plus the market value of equity over total assets, is implemented as a proxy for growth opportunities. We suppose that firms with high growth opportunities are generally more exposed to risk and hence expect that an increase in the market-to-book ratio increases exposure (see, e.g., Gezcy, et. al., 1997).

We additionally implement a measure for market power. Firms in less competitive industries are able to more easily pass-through changed costs than firms in highly competitive industries. Accordingly, they should have less exposure (for details see, e.g., Dominguez and Tesar, 2006; Bartram et al., 2010). Our proxy for market power is a *Lerner index* based on mark-up costs, which we calculate for each of the 17 industry sectors.[27] All necessary data for the Lerner index

[26] The market value of equity is calculated by multiplying a firm's common shares outstanding by their market price at the end of the fiscal year. As some companies have more than one type of common/ordinary share, the market value of equity represents the total market value of the company. In contrast to studies of the U.S. market, we treat preferred stocks as common shares (and therefore as equity capital) since German preferred stocks ("Vorzugsaktie") must have, except for the voting right, the same privileges as ordinary shares. The definition and calculation of book value of equity follows the same argumentation (and does not include hybrid capital, minority interest and non-interest reserves which are sometimes treated as equity capital).

[27] In particular, the Lerner index is computed as 1-1/mark-up; mark-up is defined as price over marginal costs. As these marginal costs of firms (and therefore also of industries) are rarely available, we follow ECB calculations and measure mark-up as the value-added over employee' compensation (see Przbyla and Roma, 2005).

calculations are drawn from the STAN database of the OECD.[28] The index ranges from 0 to 1, with high values representing less competition in the corresponding industry. Hence, the impact on exposure should be negative. It is worth noting that our Lerner index might be a rather poor proxy for market power, as it only considers the market structure of Germany, data not being available for most of the countries trading with Germany.

As a further proxy for operational strength we implement the *current asset ratio*, measured by current assets over total assets. High levels of current assets make a firm more susceptible to price changes in raw materials and inventory. Consequently, we expect that an increase in the current asset ratio will increase exposure.

The *R&D intensity*, measured by research and development expenditures over total sales, is used as a proxy for the competitive advantage of the firm.[29] High investments in research and development result in higher levels of the intangible assets of technological know-how and expertise (see Morck and Yeung, 1991) that are unique to the firm and protect it from both changes in the pricing environment and competition. Accordingly, we expect a negative relationship with exposure.

Finally, we employ a foreign currency *derivative usage dummy* that equals 1 if the firm uses derivatives in a specific year, and zero otherwise. As firms usually install such instruments to protect themselves from nominal exchange rate movements, the expected relationship is different for the different types of exposure. While we do not expect any effect on EMU exposure,

[28] The STAN database for industrial analysis includes data on output, labor input, investment and trade across countries and is primarily based on member countries' annual national accounts. As information on industry-specific value-added and employee compensation is only available for years up to 2011, we carry forward the inflation-adjusted average growth rates (of the years 2010 and 2011) to calculate the years 2012 and 2013.

[29] R&D expenditures include both direct expenses (excluding depreciation) and activated expenditures for research and development.

derivative usage should reduce Overall and ROW exposure if firms use foreign currency derivatives for hedging (see, e.g., Allayannis and Ofek, 2001; Hagelin and Pramborg, 2004).

Table 5 presents summary statistics of the explanatory variables included in our second-stage regressions.

[Table 5 about here]

We stress four distinctive features. As already mentioned, the average foreign sales ratio is 50.6%. However, the broad distribution shows that there are firms with high and low levels of foreign activity. The average ratio of foreign purchases to total sales is slightly below the foreign sales ratio, but even more widely distributed as implied by the high standard deviation. Our average firm has a debt ratio of 57.7%. Moreover, for 54.7% of all observations, firms report derivative usage. Table 6 shows pairwise correlations of the explanatory variables. While the correlations between most variables is low, we find sizeable correlations between currency derivative usage and the foreign sales ratio and firm size, respectively, suggesting that firms with export activities and larger firms are more likely to use derivatives.[30]

[Table 6 about here]

[30] In addition, the foreign sales ratio and foreign purchases/total sales are notably correlated. However, the correlation between these variables is still below a relevant level.

4.2.2 Relationships between exposure and firm characteristics

4.2.2.1 Results for all exposures

We start our second-stage analysis by applying fixed-effects regression according to Equation (5), using the estimated EMU, ROW and Overall exposures from stage-one regression as the dependent variable. Our first approach includes the absolute values of the exposures, which is in line with many papers on exchange rate exposures (see, e.g., Aggarwal and Harper, 2010). However, as already mentioned above, the explanatory variables may have symmetrical and asymmetrical effects on exposures. Thus the approach of using absolute values is well-suited to analyzing the determinants that would show symmetrical effects, though it may not reveal the links for the proxies on foreign sales and foreign purchases, as these should have asymmetrical effects. Table 7 presents the results.[31]

[Table 7 about here]

We find some statistically significant relationships between firm characteristics and EMU exposures. In particular, we find that the debt ratio, asset turnover and firm size are significantly related to EMU exposures. Lower debt ratios are associated with lower exposure, illustrating that a lower level of debt makes a firm's equity less susceptible to risk, including that from inflation differentials. The relationship for asset turnover indicates that good asset management, i.e. the efficiency of a company in deploying its assets to generate sales, protects firms from different inflation rates among the countries in the EMU. Likewise, the coefficient for size suggests that

[31] For the sake of brevity we do not tabulate the results for the alternatively estimated EMU and ROW exposures (Columns (4) and (5) of Table 3) as they are qualitatively similar to the results for the baseline EMU and ROW exposures, but they are available from the authors upon request.

larger firms are less exposed to risk due to inflation differentials vis-à-vis the trading partners within the EMU, consistent with the theory that they achieve risk reduction through geographical diversification of products, customers and production facilities. For the remaining variables we find the expected signs (unless for the market-to-book-ratio) – suggesting the economically plausible relationships that we have assumed – but no statistically significance. However, the lack of significance for some firm fundamentals is in line with many studies in the field of standard exchange rate exposure (see, e.g., He and Ng, 1998; Aggarwal and Harper, 2010; Hutson and Laing, 2014) and also applies for ROW and Overall exposures.

When looking at the regressions results of ROW and Overall exposures in detail, we first see that they are quite similar in terms of sign, magnitude and statistical significance. This is not surprising as these two types of exposure are highly correlated.[32] We find significant links for the debt ratio, asset turnover, firm size, the current asset ratio and derivative usage on exposure.[33] Accordingly, the results are analogous to the effects reported above, but also show some additional effects. The positive relationship for the current asset ratio indicates that higher levels of current assets increase a firm's susceptibility to exchange rate movements, which is in line with the theory that unfavorable currency fluctuations stronger affect the input costs for inventory and raw materials compared to long-term assets. Finally, the negative coefficient of the foreign currency derivative usage dummy supports the common assumption that firms use derivatives to hedge against nominal exchange rate movements, as the use of such instruments significantly

[32] In particular, the Pearson correlation coefficient between ROW exposures and Overall exposures is 0.98 and between EMU exposures and ROW exposures (Overall exposures) 0.12 (0.15).

[33] These findings are in accordance with our expectations and with related literature on standard exchange rate exposures (see, e.g., Doidge et al., 2006; Dominguez and Tesar, 2006, Aggarwal and Harper, 2010, among others).

reduces exchange rate risk. Only for ROW exposures do we additionally find a statistically significant link for the EBITDA margin, but the impact is very small.

However, as mentioned above, explanatory variables may have different impacts regarding the direction of the exposures, and the methodology of using absolute values may not be best suited to analyzing the determinants of exposures. Therefore, we next examine positive and negative exposures separately. Table 8 presents the results.

[Table 8 about here]

Generally, the results for EMU exposures are similar to the findings described above, though asset turnover is only significant for positive exposures. However, we now additionally find some statistically significant relationships regarding the foreign activity of firms. In particular, there is a significantly positive relationship between foreign purchases and existing negative EMU exposures. This implies that an increase in foreign purchases leads to a decrease in net exporters' exposure caused by inflation differentials within the euro area. This is what we would expect as more foreign purchases make their net export position smaller. For foreign purchases and positive exposures as well as for foreign sales and both positive and negative exposures, the signs of the coefficients also reflect the expected effects. However, they are not statistically significant. Additionally, we find a weak relationship between the Lerner index and existing negative EMU exposures. The significantly positive coefficient indicates that net exporting firms to the euro area from less competitive industry sectors are less exposed to exchange rate risk within the EMU. A possible explanation for this is that they can pass-through the effects of price changes as their products are difficult to substitute. However, as already discussed above, our Lerner index is a fairly weak proxy for market power as it only captures the German market conditions. Accordingly, these results should not be overweighed.

For ROW and Overall exposures, the results are also similar to those reported above. In addition, we also observe significant relationships for the foreign activity measures with regard to both negative and positive exposures. The links show the expected effects on standard exchange rate exposure. In particular, the positive link of foreign purchases indicates that for net exporters an increase in foreign purchases is associated with a decrease in exposure, as their existing net export positions shrink. In contrast, for net importers, an increase in foreign purchases increases their exposure as their already-existing net import position continues to grow even larger. The negative link of the foreign purchase ratio implies these effects in reverse, which is also in line with theory. The impact of the current asset ratio is now only statistically significant for positive ROW and Overall exposures and indicates that an increase in current assets increases the standard exposure of net importers. This is plausible as it is especially these firms that are affected by higher input costs, whereas net exporters may be able to pass-through such increased costs more easily. On the other hand, the derivative usage dummy is now only statistically significant for negative ROW and Overall exposures. This finding suggests that especially the standard exchange rate exposure of net exporters decreases if a firm uses derivatives. The use of foreign currency derivatives among firms with foreign sales is widely documented in the literature (see Bartram et al., 2010). Hence, the finding that net exporting firms use derivatives to reduce exposure – as already indicated by the observable correlation between the foreign sales ratio and derivative usage documented in Table 6 – is plausible.

So far, the results show that several firm characteristics that are pinpointed by theory and empirical evidence as likely to affect standard exchange rate exposure are also related to EMU exposure. In the next subsection we analyze the effects of the firm-specific variables on particularly high exposures.

4.2.2.2 Results for high exposures

First, we run logistic regressions according to Equation (6), to analyze whether a specific firm characteristic is related to the probability of a firm-year exhibiting a highly negative (10% quantile) or a highly positive (90% quantile) exposure in a specific year. Our results are reported in Table 9.

[Table 9 about here]

Most of the significant variables documented above also determine high EMU exposures. In particular, we find that larger firm size and higher asset turnover mean that a firm is less likely to have very high EMU exposure, but the effect of the latter is only statistically significant for highly negative exposures. Moreover, both foreign sales and foreign purchases are statistically significant for highly negative EMU exposures and have the expected signs. While the debt ratio and the Lerner index are not related to the probability of high EMU exposures, we now find significant links for the EBITDA margin. Though the effects are small, the negative links suggest that a higher profitability reduces the probability of facing high EMU exposures, which is consistent with theory. In contrast, the positive coefficient for highly positive exposures breaks with theory, but the effect is very small.

For ROW and Overall exposures, the significant variables are also similar to those mentioned above. Again, the proxies for foreign activity show the expected signs and are mostly significant. This indicates that both are associated with the probability of exhibiting high standard exchange rate exposures. Likewise, the coefficients of firm size, asset turnover and debt ratio show relationships in accordance with our expectations, though the effects are not always statistically significant. In addition, a higher EBITDA margin is associated with a lower probability of high exposures. Like with the fixed-effects OLS regression, we find a significant link between the derivative usage dummy and (highly) negative ROW and Overall exposures. The negative coefficient indicates that for net exporters, the use of derivatives reduces the probability of a firm being highly exposed to exchange rate risk. This finding again illustrates the relevance of derivatives for hedging foreign sales. Again, we find a link with the current asset ratio for (highly) positive exposures, suggesting that for net importers a higher share of current assets is associated with a higher probability of high exposures. Contrary to our results from fixed-effects OLS regressions, we now observe a weak positive relationship between the market-to-book ratio and (highly) negative exposures, suggesting that the higher growth opportunities of a firm are associated with a higher probability of its being highly exposed to standard exchange rate risk. This is plausible as firms with higher growth opportunities are also generally more prone to risk, including exchange rate risk. Finally, the results show partly significant negative relationships between the R&D intensity and exposures. This finding indicates that firms with higher R&D spending are less likely to exhibit high exposures, which is also in line with the expectation that competitive advantages reduce risk.

While our logistic regressions show whether a specific variable is related to the probability of a firm-year having very high exposure, we next apply unconditional quantile regression to Equation (5) to analyze the effects of the characteristics of a firm on the quantiles of the exposure distribution. Again, we are interested in the tails of the distribution, where the highly negative and highly positive exposures are located. Before analyzing these tails in more detail, we start with a graphical overview of the results for the entire distribution, illustrating the different relationships that may emerge for the different quantiles. Figures 5 and 6 present the estimated coefficients of firm characteristics including their 90%-confidence intervals, for quantiles between 10% and 90% for EMU and ROW exposures, respectively.

[Figure 5 and Figure 6 about here]

For most explanatory variables we do not find statistically significant links at the quantiles in the center, including the median. But we do find significant relationships between firm characteristics and exposures at the low and high quantiles. Table 10 reports the results for the 10% and 90% quantiles of the exposure distribution. In particular, the estimated coefficients for the 10% quantile (90% quantile) show, how the 10% quantile (90% quantile) is affected by changes in firm characteristics.

[Table 10 about here]

Generally, many of the findings from unconditional quantile regressions are consistent with those from logistic regressions. Accordingly, the results show that the identified firm characteristics are not only related to the probability of high exposure, but also shift the particular quantile of the exposure distribution. However, we also observe some differences.

In particular, for EMU exposures, we find that leverage increases high exposures, while asset turnover and firm size reduces them. Moreover, the results show the expected links between foreign activity and EMU exposure, supporting the effects outlined above. However, these relationships are not always statistically significant.

For ROW and Overall exposures, again foreign activity, firm size, asset turnover and the debt ratio are statistically significant; reinforcing the findings discussed above. Moreover, we again find that the market-to-book-ratio is weakly linked to high Overall exposures, but in contrast to logistic regressions, the relationship is significant for highly positive exposures (though not for highly negative ones). Finally, we again find that derivative usage reduces highly negative exposures to standard exchange rate risk. For the remaining variables we do not find statistically significant relationships.

Overall, the results from stage-two regressions on EMU exposures can be summarized as follows: exposure caused by inflation differentials within the EMU is determined by some firm-specific characteristics and the relationships are economically plausible. Moreover, the determinants are similar to those that are typically related to standard exchange rate exposure. In particular, we find that greater firm size lessens EMU exposure, indicating that larger firms achieve higher risk reduction through higher geographic diversification and their ability to balance their payment flows across the countries in the EMU. Likewise, higher asset turnover reduces exposure, suggesting that efficient asset management protects firms against price movements due to inflation differentials. Moreover, lower levels of debt are associated with lower exposure, illustrating that risk of a firm's equity is naturally lower for firms with less debt. Finally, we find asymmetric effects regarding foreign sales and foreign purchases. Whereas for net exporters an increase in foreign sales is associated with an increase in exposure, since this causes their already existing net export positions to expand even further, an increase in the foreign sales ratio for net importers renders the exposure less negative since their net import position becomes smaller. These effects are reversed for foreign purchases. Moreover, we do not find evidence that foreign currency derivative usage is related to EMU exposures. This is in line with our expectations, as such products are typically used to protect against nominal exchange rate movements. While these key effects are similar with the different empirical methods, implying that the economic relationships are quite robust, they are not always statistically significant.

5 Robustness tests

5.1 Robustness to alternative regression model setups

In additional tests, we check the robustness of our results. We estimate exposures by using different specifications of the first-stage regression model and perform several tests to check the robustness from stage-two regression results.

First, as some studies on exchange rate exposures use a longer return horizon than we do (monthly or quarterly returns instead of weekly returns) and/or a simple two-factor model (instead of the extended Fama-French model), we re-estimate our exposures using the Jorion-model as characterized by Equation (1) and monthly returns, respectively. While exposures from the two-factor are similar to those from our baseline regressions, we find a small increase in the number of significant exposures with increasing time horizon, which is consistent with findings from prior studies (see, e.g., Bodnar and Wong, 2003). Though, the exposure distribution is quite similar to that of our baseline estimation, the estimated exposures of the individual firm-years may differ between the estimation models. Hence, we repeat stage-two regressions using the exposures on monthly returns and the Jorion-model as the dependent variable. We find results qualitatively similar to those described above.

Second, we estimate exposures by orthogonalizing the market index. In particular, we use the residual market index return that is orthogonal to changes in the specific exchange rate indices as a variable for the market return. Like numerous other studies, we find an increase in significant exposures (see, e.g., Bartram and Bodnar, 2007). Interestingly, average exposure now is slightly positive. However, the specific coefficients of the particular firm-years are similar to those from our baseline regressions. We repeat stage-two regressions and again obtain results similar to those reported above.

Third, our findings from stage-two regressions may not show the true effects of the explanatory variables, as we are using all exposures in our analyses, irrespective of their statistical significance in our first-stage regressions. We therefore re-estimate the coefficients from stage-two regressions by using only exposures that are significant at the 10% level in the first-stage baseline regressions. However, the results remain qualitatively unchanged.

Finally, as some of the explanatory variables, such as the proxies for foreign activity or the derivative usage dummy, could have bidirectional relationships with exposure, concerns regarding endogeneity might arise. Therefore, we repeat our baseline regressions using one-yearlagged firm characteristics as explanatory variables. Generally, the results corroborate the effects on EMU exposures of the debt ratio, asset turnover, firm size and foreign activity.

5.2 Inflation differentials vis-à-vis the countries from the ROW

In a final step, we investigate whether the observed effects on EMU exposures are also applicable to risk arising from inflation differentials vis-à-vis the countries outside the EMU. For this, we separate the fraction of ROW exposures that stem from inflation differentials vis-à-vis the ROW from those stemming from nominal exchange rate movements. Hence, we split the ROW exchange rate indices and construct industry-specific ROW exchange rate indices, including the trade-weighted nominal exchange rates based on trade with the ROW countries (ROW Nominal exchange rate index) and ROW exchange rate indices including only the trade-weighted inflation differentials between Germany and the ROW countries (ROW Inflation differentials exchange rate index), respectively. Accordingly, the ROW Inflation differentials exchange rate indices can be seen as the pendant to the EMU exchange rate indices.

Again, we estimate yearly exposure using the extended Fama-French model as presented in Equation (2) using weekly returns with particular trade-weighted industry-specific exchange rate indices and standardized exchange rate index returns. Table 11 presents the estimated exposures.

[Table 11 about here]

Average ROW Infl-diff exposure is -0.021. Again, we investigate positive and negative exposures separately and find that average positive exposure is 0.572 and average negative exposure is -0.585. Moreover, we find that average ROW Infl-diff exposure is almost as large as average ROW Nominal exposure, especially when we look at positive and negative exposures separately. Accordingly, the results show economically significant exposures due to inflation differentials between Germany and the ROW countries. Hence, the results support the findings regarding EMU exposures, that inflation differentials among the trading-partners create "exchange rate risk".[34]

We again relate the estimated exposures to our set of firm characteristics. Table 12 reports the results of applying fixed-effects regressions, for positive and negative exposures separately.

[Table 12 about here]

The results for ROW Infl-diff exposures are quite similar to those for EMU exposures. In particular, we also find that debt ratio, asset turnover and firm size have significant effects on exposures. However, unlike with EMU exposures we do not find evidence that foreign activity is related to ROW Infl-diff exposures. Hence, the results largely support the key findings from EMU exposures.[35]

6 Conclusion

In this paper, we analyze the exchange rate exposure of German firms for the years 2004 to 2013 by measuring exposure as the sensitivity of a firm's stock returns to changes in an exchange rate index. As expected, German firms are generally exposed to standard exchange rate risk. Even

[34] Columns (3) and (4) of Table 11 show that the results for ROW Nominal exposure and ROW Infl-diff exposure are similar if the exposures are estimated jointly in one regression rather than separately in two different regressions.

[35] We also run fixed-effects regressions with absolute values, logistic regressions and unconditional quantile regressions. The results and key findings are quite similar as reported extensively above. For the sake of brevity we do not tabulate the results, but they are available from the authors upon request.

more interestingly, we find economically significant "exchange rate risk" within the EMU, suggesting that German firms are exposed to risk from inflation differentials between Germany and the other EMU countries. Actually, average EMU exposure is fairly large. Indeed, it is almost as large as the exposure arising from trade outside the euro area. However, such risk from different inflation rates between the trading partners is difficult to hedge as many of the conventional instruments to mitigate risk, like foreign currency derivatives, are not an option.

The estimated exposures show large cross-sectional variation, but also a certain persistence at firm level over time. This finding suggests that exposures may result from firms' business models and their individual characteristics. Our key results imply that firms of larger size and efficient asset management are less exposed to inflation differentials. These findings are plausible as larger firms may achieve risk reduction via geographical diversification, and efficient asset management protects them from price changes. Also in line with our expectations, higher levels of debt increase EMU exposure, suggesting that firms with higher financial risk are more prone to additional risk, including that from inflation differentials. Furthermore, we find that foreign business activity affects exposure, although the effects depend on whether the firm is a net exporting or net importing one.

Generally, all of the effects mentioned also apply to ROW and Overall exposures. In contrast, the risk-reducing effect of derivative usage is solely significant for standard exchange rate risk. This is also in line with our expectations and supports the notion that risk from inflation differentials among the countries in the EMU is difficult to manage.

Overall, the results of our paper provide some important insights for the risk management of firms. While standard exchange rate risk is generally professionally managed by companies, the economic relevance of exposure due to inflation differentials described here is usually underestimated in the context of firms' "exchange rate risk". Classic instruments, such as currency derivatives, cannot be applied to mitigate such risk, as these are generally used to hedge against nominal exchange rate risk. Our results therefore highlight the challenges for the risk management policies of firms and the need for appropriate products to reduce such risk, as the market for macro derivatives, like inflation swaps, is still poorly developed.

Appendix A: Weight calculation

Weight calculations are based on Turner and Van't dack (1993). Consider: The basket consists of *N* trading partner countries of Germany. There are k foreign country markets and h foreign country producers. Germany trades bilaterally with country *i,* which is part of the basket. Moreover, Germany's exports compete with country *i*'s exports and all other exports of countries *h* in the markets of countries *k*. Therefore, the weight of country *i* in Germany's exchange rate basket reflects import competition, direct export competition and third-market competition, and can be expressed as:

Import weight $$w_i^{IM} = \frac{m_{GER}^i}{m_{GER}}$$

Export weight $$w_i^{EX} = \left[\left(\frac{x_{GER}^i}{x_{GER}}\right) \times \left(\frac{y_i}{y_i + \sum_h x_h^i}\right)\right] + \left[\sum_{k \neq i}\left(\frac{x_{GER}^k}{x_{GER}}\right) \times \left(\frac{x_i^k}{y_k + \sum_h x_h^k}\right)\right]$$

Overall weight $$w_i = \left(\frac{m_{GER}}{x_{GER} + m_{GER}}\right) \times w_i^{IM} + \left(\frac{x_{GER}}{x_{GER} + m_{GER}}\right) \times w_i^{EX}$$

where:

m_{GER} (x_{GER}) = Germany's total imports from (exports to) the basket countries *N*

m_{GER}^i (x_{GER}^i) = Germany's imports from (exports to) country *i*

y_i = Country *i*'s home supply of its domestic gross output

$\sum_h x_h^i$ = The sum of exports from countries *h* (excluding Germany) to country *i*

w_i^{IM}: The import weight of country *i* is the simple share of Germany's imports from country *i* as part of Germany's total imports. The higher the share, the more dependent Germany is on imports from country i, and thus the variations in country *i*'s exchange rate have a greater effect on Germany's economy; country i should therefore weigh more in Germany's exchange rate index.

w_i^{EX}: The export country i weight is "double-weighted" and involves direct export competition and third-market competition.

The first term on the right-hand side measures direct export competition. It consists of the simple share of Germany's exports to country *i* as part of Germany's total exports. Again, the higher the bilateral export share the more dependent Germany is on exports to country *i*. Consequently, the variations in country *i*'s exchange rate have a stronger effect on Germany's economy and country *i* should weigh more in Germany's exchange rate index. However, the share is multiplied by a measure of the openness of country *i*. The rationale behind this is as follows: if country *i* provides its overall supply (home supply of domestic gross output of country *i* plus imports from all other countries *h*) largely by domestic products and services, it is relatively less open to trade. Accordingly, Germany's exports to country *i* face stronger competition with country *i*'s domestic firms. Consequently, the effects of country *i*'s exchange rate variations are even stronger. Hence, country *i* should be given more weight in Germany's exchange rate index.

The second term on the right-hand side measures third-market competition and captures the fact that Germany competes with country *i* in many other countries *k*. From Germany's perspective, if the other countries k are an important market for Germany's exports – as measured by the bilateral export shares of countries k – and/or if country i's exports to countries k account for a large share of countries k's market – as measured by country i's exports (to countries k) in countries k's domestic supplies – then country i is an important competitor to Germany in the third markets and hence should be given more weight in Germany's exchange rate index.

w_i: The overall weight of country i is calculated by weighting the import and export weights with the relative size of total imports and total exports in Germany's total trade.

Appendix B: Country list for exchange rate index calculation

EMU exchange rate index	Austria, Belgium, Finland, France, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain *Slovenia (since 2007), Malta (since 2008), Cyprus (since 2008), Slovak Republic (since 2009), Estonia (since 2011)*
ROW exchange rate index	Australia, Argentina, Brazil, Bulgaria, Canada, Chile, China, Chinese Taipei, Colombia, Croatia, Czech Republic, Denmark, Hong Kong, Hungary, Iceland, India, Indonesia, Israel, Japan, Korea, Latvia, Lithuania, Malaysia, Mexico, New Zealand, Norway, Poland, Philippines, Romania, Russia, Saudi Arabia, Singapore, South Africa, Switzerland, Sweden, Thailand, Turkey, United Kingdom, United States *Slovenia (until 2006), Malta (until 2007), Cyprus (until 2007), Slovak Republic (until 2008), Estonia (until 2010)*

This Table presents the countries that are included in the exchange rate index calculations.

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Table 1
Industry list

Industry sector	Description	SIC Codes	Firms	Firm-years
AGR	Agriculture, hunting, forestry and fishing	01-09	3	25
BFP	Basic metals and fabricated metal products	33-34	13	102
BUS	Business services	73	49	387
CMP	Chemicals and non-metallic mineral products	28-30, 32	48	335
CON	Construction	15-17	7	51
EGW	Electricity, gas and water supply	49	11	81
EOQ	Electrical and optical equipment	36, 38	52	387
FBT	Food products, beverages and tobacco	20-21	8	43
MEN	Machinery and equipment, nec	35	55	456
MNR	Manufacturing nec; recycling	25, 39	5	44
MQA	Mining and quarrying	10-14	2	20
OSE	Other services	72, 75-89, 91-99	28	235
TLF	Textiles, textile products, leather and footwear	22-23, 31	13	72
TPT	Transport and storage, post and telecommunication	40-48	19	159
TRQ	Transport equipment	37	17	139
WPP	Wood, paper, paper products, printing and publishing	24, 26, 27	14	88
WRH	Wholesale and retail trade; Hotels and restaurants	50-59, 70	34	244
Total			**378**	**2,868**

This Table presents the 17 industry sectors with their corresponding SIC codes, the number of firms that are categorized into the group and the number of observations.

Table 2
Summary statistics

	No. Obs.	Mean	Median	10% quantile	90% quantile	Std. dev.
Panel A						
CDAX total returns (weekly)	520	0.0018	0.0043	-0.0292	0.0310	0.0279
Firms' equity total returns (weekly)	148,342	0.0028	-0.0001	-0.0574	0.0640	0.0720
Panel B						
Total Sales (millions)	2,868	4,663.55	329.82	55.59	9,094.00	15,569.77
Total Assets (millions)	2,868	6,135.76	282.18	56.36	8,728.40	24,016.31
Firm market value (millions)	2,868	7,475.52	387.87	66.84	12,507.78	26,735.76
Foreign sales/ total sales	2,868	0.506	0.545	0.056	0.858	0.292

Panel A reports the summary statistics of the market and equity returns utilized in stage-one regressions. Panel B gives a brief overview of selected firm variables.

Table 3
Estimated exposures

		Single estimation			Joint estimation	
		EMU exposure	ROW exposure	Overall exposure	EMU exposure	ROW exposure
		(1)	(2)	(3)	(4)	(5)
Full Sample	N	2,868	2,868	2,868	2,868	2,868
	Mean (equally weighted)	**-0.039**	**-0.069**	**-0.062**	**-0.050**	**-0.081**
	Mean (value-weighted)	-0.249	-0.175	-0.169	-0.283	-0.223
	Median	-0.030	-0.056	-0.051	-0.043	-0.063
	90% quantile	0.765	0.928	0.918	0.779	0.961
	10% quantile	-0.861	-1.098	-1.086	-0.927	-1.162
	Std. deviation	0.993	1.002	0.987	1.025	1.029
	Significant at 10% level	12.90%	14.57%	14.71%	13.32%	14.02%
Positives	N	1,371	1,349	1,350	1,344	1,337
	Mean (equally weighted)	**0.539**	**0.656**	**0.652**	**0.556**	**0.668**
	Mean (value-weighted)	0.318	0.337	0.331	0.328	0.347
	Std. deviation	0.899	0.709	0.710	0.915	0.719
	Significant at 10% level	10.94%	12.82%	13.26%	11.68%	12.12%
Negatives	N	1,497	1,519	1,518	1,524	1,531
	Mean (equally weighted)	**-0.569**	**-0.714**	**-0.697**	**-0.585**	**-0.735**
	Mean (value-weighted)	-0.769	-0.631	-0.613	-0.821	-0.721
	Std. deviation	0.750	0.754	0.731	0.793	0.783
	Significant at 10% level	14.70%	16.13%	16.01%	14.76%	15.68%
Significant exposure (at 10% level)	N positives	150	173	179	157	162
	Mean positives (equally w.)	**1.190**	**1.424**	**1.416**	**1.201**	**1.486**
	Mean positives (value-w.)	0.980	0.988	0.922	0.977	0.959
	N negatives	220	245	243	225	240
	Mean negatives (equally w.)	**-1.254**	**-1.508**	**-1.480**	**-1.315**	**-1.581**
	Mean negatives (value-w.)	-0.581	-1.312	-1.266	-0.577	-1.055

This Table reports the pooled exposures for the 2,868 firm-years estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific exchange rate indices. The returns of the exchange rate indices are standardized. The estimated exposures are reported separately for the full sample, positive and negative exposures, and only for significant exposures. Single estimation means that the regression is run for each index separately while in the joint estimation both indices are included in the regression as independent variables.

Table 4
Transition frequency of exposures

Dummy	EMU exposure		ROW exposure		Overall exposure	
Preceding firm-year	Following firm-year		Following firm-year		Following firm-year	
	0	**1**	**0**	**1**	**0**	**1**
0	82.78	17.22	83.21	16.79	83.37	16.63
1	72.88	27.12	72.42	27.58	72.15	27.85

This Table shows transition frequencies of a dummy that equals 1 if a firm's yearly exposure is high, i.e. below the 10% quantile or above the 90% quantile of the exposure distribution in a specific year, and zero otherwise. Exposures are estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific exchange rate indices. The returns of the exchange rate indices are standardized.

Table 5
Summary statistics of the explanatory variables

	No. Obs.	Mean	Median	10% quantile	90% quantile	Std. dev.
Foreign sales ratio	2,868	0.506	0.545	0.056	0.858	0.292
Foreign purchases/ total sales	2,868	0.488	0.382	0.058	0.867	0.539
Debt ratio	2,868	0.577	0.585	0.300	0.808	0.225
Asset turnover	2,868	1.195	1.084	0.523	1.980	0.655
EBITDA margin	2,868	0.111	0.112	0.019	0.223	0.157
Size (log of equity market value)	2,868	5.677	5.321	3.325	8.729	2.068
Market-to-book ratio	2,868	1.467	1.229	0.892	2.287	0.835
Lerner index	2,868	0.405	0.361	0.279	0.695	0.153
Current assets ratio	2,868	0.529	0.544	0.259	0.764	0.191
R&D intensity	2,868	0.033	0.009	0.000	0.100	0.055
FX derivative usage dummy	2,868	0.547	1.000	0.000	1.000	0.498

This Table reports summary statistics of the explanatory variables for stage-two regressions.

Table 6
Correlation between the explanatory variables

	Foreign sales ratio	Foreign purchases/ total sales	Debt ratio	Asset turnover	EBITDA margin	Size	Market-to-book ratio	Lerner index	Current assets ratio	R&D intensity	FX derivative usage dummy
Foreign sales ratio	1.00										
Foreign purchases/ total sales	0.49	1.00									
Debt ratio	-0.02	-0.03	1.00								
Asset turnover	-0.12	0.02	0.12	1.00							
EBITDA margin	-0.07	-0.04	-0.08	-0.07	1.00						
Size	0.29	0.19	-0.01	-0.19	0.06	1.00					
Market-to-book ratio	0.02	0.05	-0.10	0.08	-0.04	0.25	1.00				
Lerner index	-0.22	-0.12	-0.10	0.05	-0.02	-0.03	0.11	1.00			
Current assets ratio	0.16	0.05	-0.16	0.39	-0.10	-0.22	0.18	-0.04	1.00		
R&D intensity	0.26	0.08	-0.21	-0.27	-0.02	0.03	0.16	0.09	0.13	1.00	
FX derivative usage dummy	0.45	0.22	0.10	-0.06	-0.04	0.48	-0.01	-0.19	0.01	0.05	1.00

This Table reports Pearson correlation coefficients between the explanatory variables.

Table 7
Fixed-effects OLS regressions: absolute values of exposures

		All exposures		
		EMU	ROW	Overall
Variable name	Hyp.	(1)	(2)	(3)
Foreign sales ratio		0.090 (0.806)	0.052 (0.455)	0.044 (0.349)
Foreign purchases/ total sales		-0.050 (-0.753)	-0.028 (-0.384)	-0.028 (-0.370)
Debt ratio	+	0.274*** (7.819)	0.405*** (4.396)	0.402*** (4.212)
Asset turnover	-	-0.068** (-2.599)	-0.113*** (-3.102)	-0.117*** (-3.178)
EBITDA margin	-	-0.000 (-0.195)	0.000** (2.296)	0.000 (1.232)
Size	-	-0.054*** (-3.560)	-0.079*** (-5.675)	-0.078*** (-5.734)
Market-to-book ratio	+	-0.008 (-0.294)	0.027 (1.164)	0.029 (1.119)
Lerner index	-	-1.287 (-1.357)	-0.038 (-0.067)	0.001 (0.002)
Current asset ratio	+	0.150 (1.528)	0.319** (2.540)	0.306** (2.586)
R&D intensity	-	-0.066 (-0.303)	-0.239 (-0.753)	-0.176 (-0.497)
Derivate usage dummy	-	-0.085 (-1.266)	-0.086** (-2.802)	-0.092*** (-3.091)
Intercept		1.059** (2.860)	1.030*** (5.133)	0.996*** (4.335)
Observations		2868	2868	2868
Adj. R-squared		0.041	0.109	0.105
Industry fixed-effects		Yes	Yes	Yes
Year fixed-effects		Yes	Yes	Yes

This Table reports results from fixed-effects OLS regressions according to Equation (5) using the absolute values of the exposures estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific exchange rate indices as the dependent variable. The returns of the exchange rate indices are standardized. T-statistics are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using clustered standard errors.

Table 8
Fixed-effects OLS regressions: negative and positive exposures

		Negative exposures				Positive exposures		
		EMU	ROW	Overall		EMU	ROW	Overall
Variable name	Hyp.	(1)	(2)	(3)	Hyp.	(4)	(5)	(6)
Foreign sales ratio	-	-0.220	-0.454***	-0.517***	-	-0.094	-0.470**	-0.558***
		(-1.598)	(-3.151)	(-3.659)		(-0.583)	(-2.879)	(-3.018)
Foreign purchases/ total sales	+	0.167**	0.224**	0.263***	+	0.100	0.239**	0.297**
		(2.888)	(2.416)	(3.476)		(0.867)	(2.165)	(2.458)
Debt ratio	-	-0.327***	-0.370***	-0.343**	+	0.234***	0.439**	0.461***
		(-3.316)	(-3.332)	(-2.822)		(3.208)	(2.848)	(3.661)
Asset turnover	+	0.067	0.133***	0.124*	-	-0.060*	-0.092*	-0.119***
		(1.734)	(3.007)	(2.104)		(-2.079)	(-2.004)	(-3.868)
EBITDA margin	+	0.000	0.000	0.000	-	0.000	0.000***	0.000
		(0.328)	(0.896)	(0.601)		(0.147)	(3.301)	(1.729)
Size	+	0.054***	0.087***	0.093***	-	-0.056***	-0.070***	-0.063***
		(3.245)	(3.672)	(3.977)		(-3.233)	(-5.035)	(-4.285)
Market-to-book ratio	-	-0.017	-0.043	-0.047	+	-0.031	0.006	0.013
		(-0.689)	(-1.609)	(-1.662)		(-1.068)	(0.207)	(0.403)
Lerner index	+	2.696*	0.636	0.689	-	0.355	0.755	0.766
		(1.957)	(1.002)	(0.873)		(0.684)	(1.512)	(1.421)
Current asset ratio	-	-0.156	-0.291	-0.217	+	0.145	0.390***	0.430***
		(-1.544)	(-1.626)	(-1.275)		(1.139)	(3.507)	(4.616)
R&D intensity	+	-0.183	0.451	0.399	-	-0.196	0.179	0.197
		(-0.518)	(1.282)	(1.024)		(-0.689)	(0.418)	(0.423)
Derivate usage dummy	+	0.099	0.154**	0.116*	-	-0.075	-0.002	-0.058
		(1.090)	(2.624)	(1.772)		(-0.956)	(-0.061)	(-1.422)
Intercept		-1.528***	-1.332***	-1.330***		0.512*	0.623**	0.611**
		(-3.156)	(-6.596)	(-4.938)		(1.856)	(2.832)	(2.706)
Observations		1497	1519	1518		1371	1349	1350
Adj. R-squared		0.050	0.118	0.109		0.036	0.111	0.116
Industry fixed-effects		Yes	Yes	Yes		Yes	Yes	Yes
Year fixed-effects		Yes	Yes	Yes		Yes	Yes	Yes

This Table reports results from fixed-effects OLS regressions according to Equation (5) using the exposures estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific exchange rate indices as the dependent variable. The returns of the exchange rate indices are standardized. Results are reported separately for negative and positive exposures. T-statistics are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using clustered standard errors.

Table 9
Logistic regressions: high exposures (10% and 90% quantile)

	D = 1 if exposure below 10% quantile				D = 1 if exposure above 90% quantile			
		EMU	ROW	Overall		EMU	ROW	Overall
Variable name	Hyp.	(1)	(2)	(3)	Hyp.	(4)	(5)	(6)
Foreign sales ratio	-	0.702* (1.669)	1.313** (2.382)	1.600*** (2.743)	-	-0.593 (-1.631)	-1.695*** (-3.624)	-1.763*** (-3.282)
Foreign purchases/ total sales	+	-0.572* (-1.726)	-0.439 (-1.136)	-0.672* (-1.775)	+	0.422 (1.205)	0.873** (2.295)	1.012** (2.385)
Debt ratio	-	0.327 (1.395)	0.453** (1.961)	0.458* (1.776)	+	0.485 (1.588)	0.579 (1.553)	0.607* (1.906)
Asset turnover	+	-0.231* (-1.798)	-0.183 (-1.107)	-0.310* (-1.719)	-	-0.107 (-0.819)	-0.217 (-1.476)	-0.264* (-1.881)
EBITDA margin	+	-0.010*** (-4.490)	-0.003** (-2.169)	-0.004** (-2.419)	-	0.002*** (5.322)	-0.030** (-2.575)	-0.029** (-2.565)
Size	+	-0.216*** (-5.484)	-0.230*** (-3.575)	-0.239*** (-3.515)	-	-0.251*** (-3.079)	-0.238*** (-3.147)	-0.228*** (-3.149)
Market-to-book ratio	-	0.083 (0.880)	0.124 (1.607)	0.141* (1.725)	+	0.005 (0.035)	0.137 (1.247)	0.159 (1.413)
Lerner index	+	-1.848 (-0.740)	-1.320 (-0.783)	-0.467 (-0.240)	-	0.479 (0.162)	1.302 (0.608)	1.321 (0.635)
Current asset ratio	-	0.462 (0.987)	0.163 (0.328)	0.346 (0.791)	+	0.461 (1.037)	0.284 (1.091)	0.508* (1.747)
R&D intensity	+	-2.077 (-1.033)	-0.741 (-0.784)	-1.830* (-1.924)	-	1.127 (1.317)	-2.164*** (-3.753)	0.132 (0.068)
Derivate usage dummy	+	-0.433 (-1.019)	-0.345*** (-3.376)	-0.280** (-2.191)	-	-0.259 (-0.957)	0.081 (0.508)	0.043 (0.395)
Observations		2868	2868	2868		2868	2868	2868
Pseudo R-squared		0.046	0.077	0.080		0.068	0.070	0.068
Industry fixed-effects		Yes	Yes	Yes		Yes	Yes	Yes
Year fixed-effects		Yes	Yes	Yes		Yes	Yes	Yes

This Table reports results from logistic regressions according to Equation (6) using the exposures estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific exchange rate indices. The returns of the exchange rate indices are standardized. The dependent variables are binary variables that equal 1 if the yearly exposure is below the 10% quantile or above the 90% quantile of the exposure distribution of that year, respectively, and zero otherwise. T-statistics are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using clustered standard errors.

Table 10
Unconditional quantile regressions: high exposures (10% and 90% quantile)

	10% quantile				**90% quantile**			
		EMU	ROW	Overall		EMU	ROW	Overall
Variable name	Hyp.	(1)	(2)	(3)	Hyp.	(4)	(5)	(6)
Foreign sales ratio	-	-0.318	-0.854**	-1.065***	-	-0.193	-0.822***	-0.753***
		(-1.533)	(-2.509)	(-3.027)		(-1.126)	(-2.732)	(-2.836)
Foreign purchases/ total sales	+	0.230*	0.257	0.411*	+	0.139	0.405*	0.418**
		(1.746)	(1.322)	(1.881)		(1.320)	(1.849)	(2.331)
Debt ratio	-	-0.238	-0.519***	-0.557**	+	0.313**	0.446**	0.487**
		(-1.643)	(-2.681)	(-2.511)		(2.082)	(2.190)	(2.384)
Asset turnover	+	0.096*	0.137*	0.228***	-	-0.051	-0.146**	-0.164***
		(1.688)	(1.720)	(2.905)		(-0.812)	(-2.040)	(-2.774)
EBITDA margin	+	0.000	-0.000	-0.000	-	0.001	-0.001	-0.000
		(0.336)	(-0.134)	(-0.284)		(0.970)	(-0.336)	(-0.373)
Size	+	0.085***	0.139***	0.150***	-	-0.090***	-0.098***	-0.093***
		(4.706)	(4.850)	(4.820)		(-4.835)	(-4.042)	(-4.036)
Market-to-book ratio	-	-0.037	-0.077	-0.091	+	-0.000	0.050	0.066*
		(-1.010)	(-1.410)	(-1.501)		(-0.002)	(1.079)	(1.691)
Lerner index	+	1.062	0.861	0.237	-	0.033	0.599	0.534
		(1.151)	(0.623)	(0.159)		(0.041)	(0.600)	(0.568)
Current asset ratio	-	-0.218	-0.159	-0.309	+	0.224	0.229	0.326
		(-1.106)	(-0.562)	(-1.125)		(1.192)	(0.998)	(1.625)
R&D intensity	+	0.746	0.405	1.136	-	0.647	-0.931	0.138
		(0.997)	(0.409)	(1.209)		(1.004)	(-1.375)	(0.160)
Derivate usage dummy	+	0.145	0.243**	0.206*	-	-0.063	0.014	-0.009
		(0.929)	(1.999)	(1.670)		(-0.331)	(0.165)	(-0.094)
Intercept		-1.901***	-2.279**	-1.844*		0.571	0.701	0.737
		(-2.831)	(-2.385)	(-1.766)		(0.909)	(0.993)	(1.002)
Observations		2868	2868	2868		2868	2868	2868
Adj. R-squared		0.029	0.039	0.042		0.034	0.040	0.040
Industry fixed-effects		Yes	Yes	Yes		Yes	Yes	Yes
Year fixed-effects		Yes	Yes	Yes		Yes	Yes	Yes

This Table reports results from unconditional quantile regressions to Equation (5) at the 10% and 90% quantiles using the exposures estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific exchange rate indices as the dependent variable. The returns of the exchange rate indices are standardized. T-statistics are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using robust standard errors bootstrapped from 1,000 replications.

Table 11
Estimated exposures for ROW

		Single estimation		Joint estimation	
		ROW Infl-diff exposure	ROW Nominal exposure	ROW Infl-diff exposure	ROW Nominal exposure
		(1)	(2)	(3)	(4)
Full Sample	N	2,868	2,868	2,868	2,868
	Mean (equally weighted)	**-0.021**	**-0.061**	**-0.032**	**-0.065**
	Mean (value-weighted)	-0.089	-0.185	-0.110	-0.195
	Median	-0.017	-0.033	-0.024	-0.041
	90% quantile	0.849	0.960	0.863	0.983
	10% quantile	-0.905	-1.096	-0.933	-1.138
	Std. deviation	0.880	1.017	0.905	1.035
	Significant at 10% level	14.44%	14.61%	14.68%	14.02%
Positives	N	1,398	1,373	1,393	1,366
	Mean (equally weighted)	**0.572**	**0.657**	**0.580**	**0.672**
	Mean (value-weighted)	0.280	0.353	0.294	0.362
	Std. deviation	0.708	0.715	0.727	0.730
	Significant at 10% level	13.66%	12.45%	13.42%	12.15%
Negatives	N	1,470	1,495	1,475	1,502
	Mean (equally weighted)	**-0.585**	**-0.721**	**-0.609**	**-0.735**
	Mean (value-weighted)	-0.441	-0.679	-0.492	-0.702
	Std. deviation	0.617	0.778	0.637	0.787
	Significant at 10% level	15.17%	16.59%	15.86%	15.71%
Significant exposure (at 10% level)	N positives	191	171	187	166
	Mean positives (equally w.)	**1.215**	**1.456**	**1.225**	**1.490**
	Mean positives (value-w.)	0.565	0.809	0.540	0.991
	N negatives	223	248	234	236
	Mean negatives (equally w.)	**-1.298**	**-1.536**	**-1.316**	**-1.603**
	Mean negatives (value-w.)	-0.909	-1.517	-0.910	-1.492

This Table reports the pooled exposures for the 2,868 firm-years estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific exchange rate indices. The returns of the exchange rate indices are standardized. The estimated exposures are reported separately for the full sample, positive and negative exposures, and only for significant exposures. Single estimation means that the regression is run for each index separately while in the joint estimation both indices are included in the regression as independent variables.

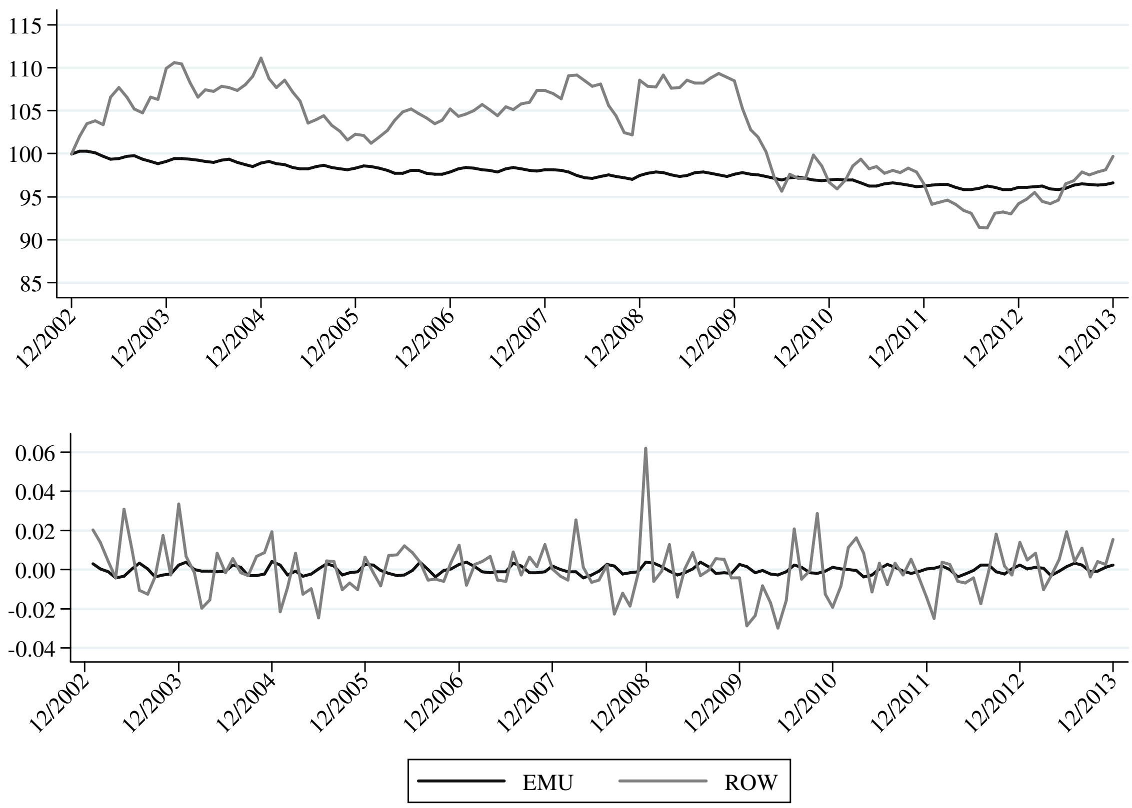
Table 12
Fixed-effects OLS regressions for ROW: negative and positive exposures

	Negative exposures			**Positive exposures**		
		ROW Infl-diff	ROW Nominal		ROW Infl-diff	ROW Nominal
Variable name	Hyp.	(1)	(2)	Hyp.	(3)	(4)
Foreign sales ratio	-	0.031 (0.186)	-0.462** (-2.616)	-	-0.127 (-0.803)	-0.439*** (-3.110)
Foreign purchases/ total sales	+	0.008 (0.090)	0.218** (2.150)	+	0.045 (0.571)	0.214** (2.291)
Debt ratio	-	-0.237** (-2.869)	-0.405*** (-3.501)	+	0.283** (2.797)	0.424** (2.498)
Asset turnover	+	0.084 (1.460)	0.148*** (4.741)	-	-0.083*** (-3.572)	-0.068 (-1.724)
EBITDA margin	+	-0.000 (-0.399)	-0.000 (-0.143)	-	-0.001** (-2.418)	0.000*** (3.354)
Size	+	0.051*** (3.403)	0.092*** (3.954)	-	-0.066*** (-3.700)	-0.061*** (-4.318)
Market-to-book ratio	-	-0.012 (-0.493)	-0.312 (-1.730)	+	-0.024 (-1.334)	0.001 (0.030)
Lerner index	+	-0.629 (-1.192)	0.764 (0.704)	-	0.293 (0.577)	0.846* (1.860)
Current asset ratio	-	-0.134 (-0.863)	-0.053* (-1.901)	+	0.204 (1.664)	0.408*** (4.849)
R&D intensity	+	0.312 (0.586)	0.869** (2.801)	-	0.292 (0.476)	0.460 (1.177)
Derivate usage dummy	+	0.056 (1.719)	0.147* (2.090)	-	0.009 (0.076)	0.020 (0.088)
Intercept		-0.364 (-1.443)	-1.424*** (-3.410)		0.571** (2.383)	0.476** (2.347)
Observations		1470	1495		1398	1373
Adj. R-squared		0.057	0.116		0.050	0.101
Industry fixed-effects		Yes	Yes		Yes	Yes
Year fixed-effects		Yes	Yes		Yes	Yes

This Table reports results from fixed-effects OLS according to Equation (5) using the exposures estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific exchange rate indices as the dependent variable. The returns of the exchange rate indices are standardized. Results are reported separately for negative and positive exposures. T-statistics are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using clustered standard errors.

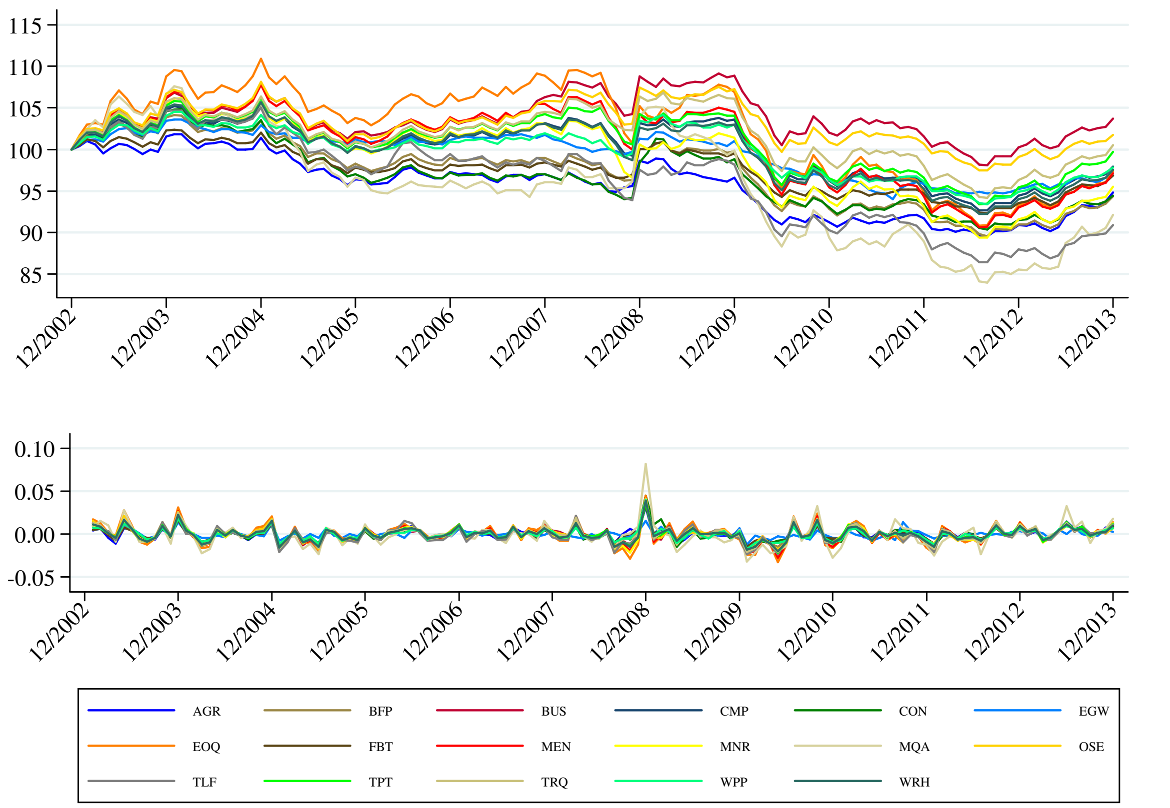
Figure 1

Development of trade-weighted exchange rate indices: EMU vs. ROW



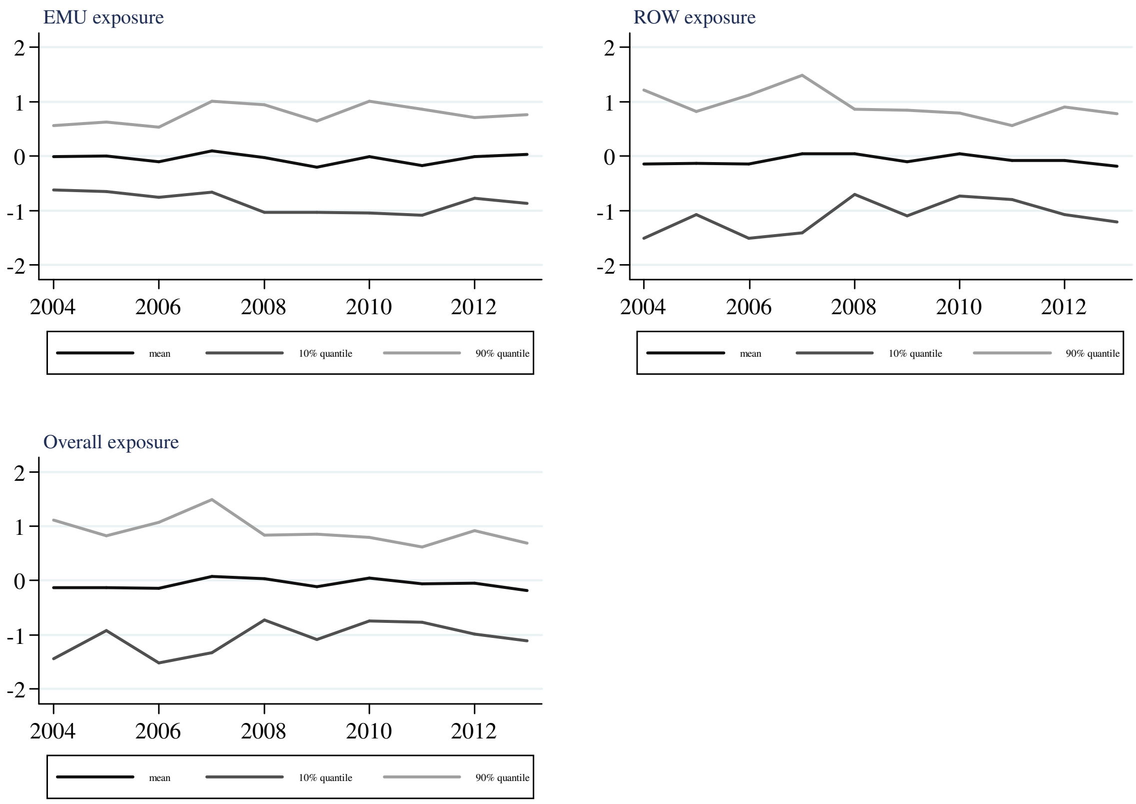
This Figure presents the development of the trade-weighted EMU exchange rate index and the trade-weighted ROW exchange rate index and the corresponding relative monthly changes.

Figure 2
Development of trade-weighted industry-specific exchange rate indices



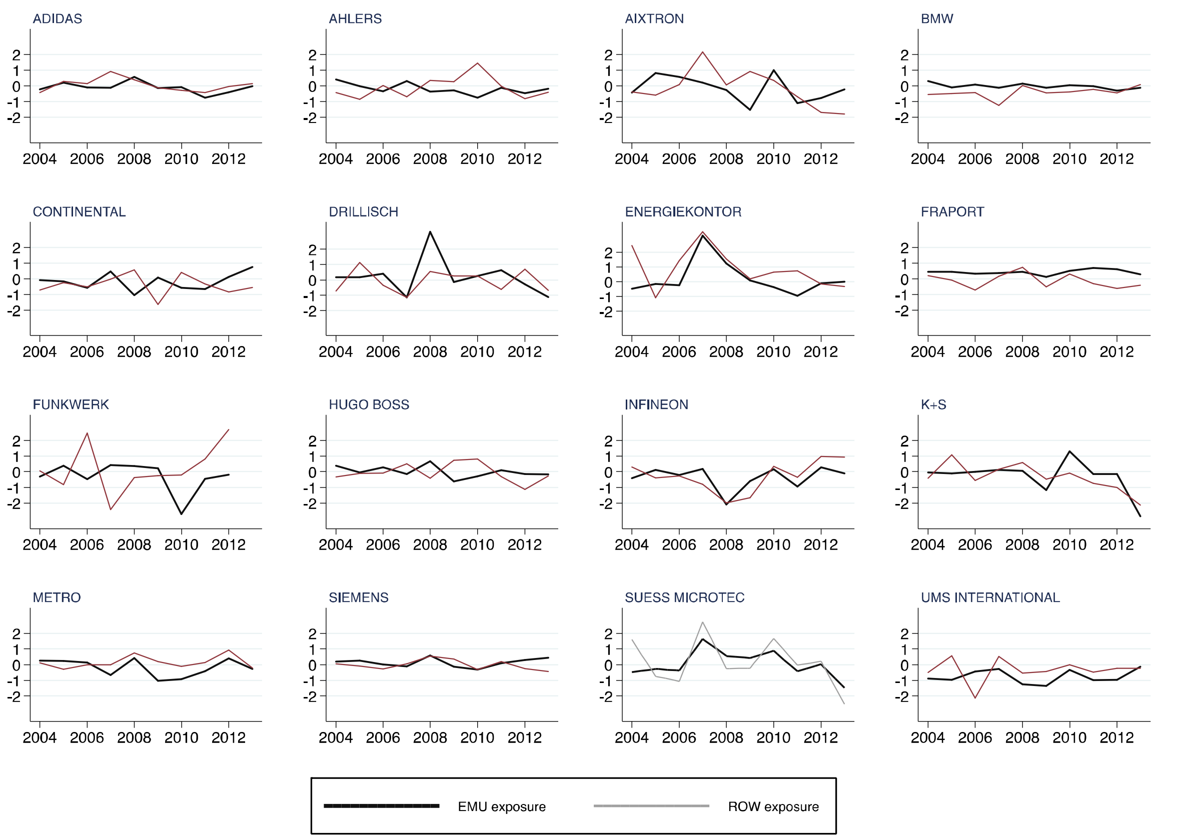
This Figure presents the development of the industry-specific trade-weighted Overall exchange rate indices and the corresponding relative monthly changes. See Table 1 for information about the abbreviations.

Figure 3
Development of cross-sectional distribution of exposure over time



This Figure shows the development of the cross-sectional distribution of exposures for means, 10% and 90% quantiles over the sample period for exposures estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific exchange rate indices. The returns of the exchange rate indices are standardized.

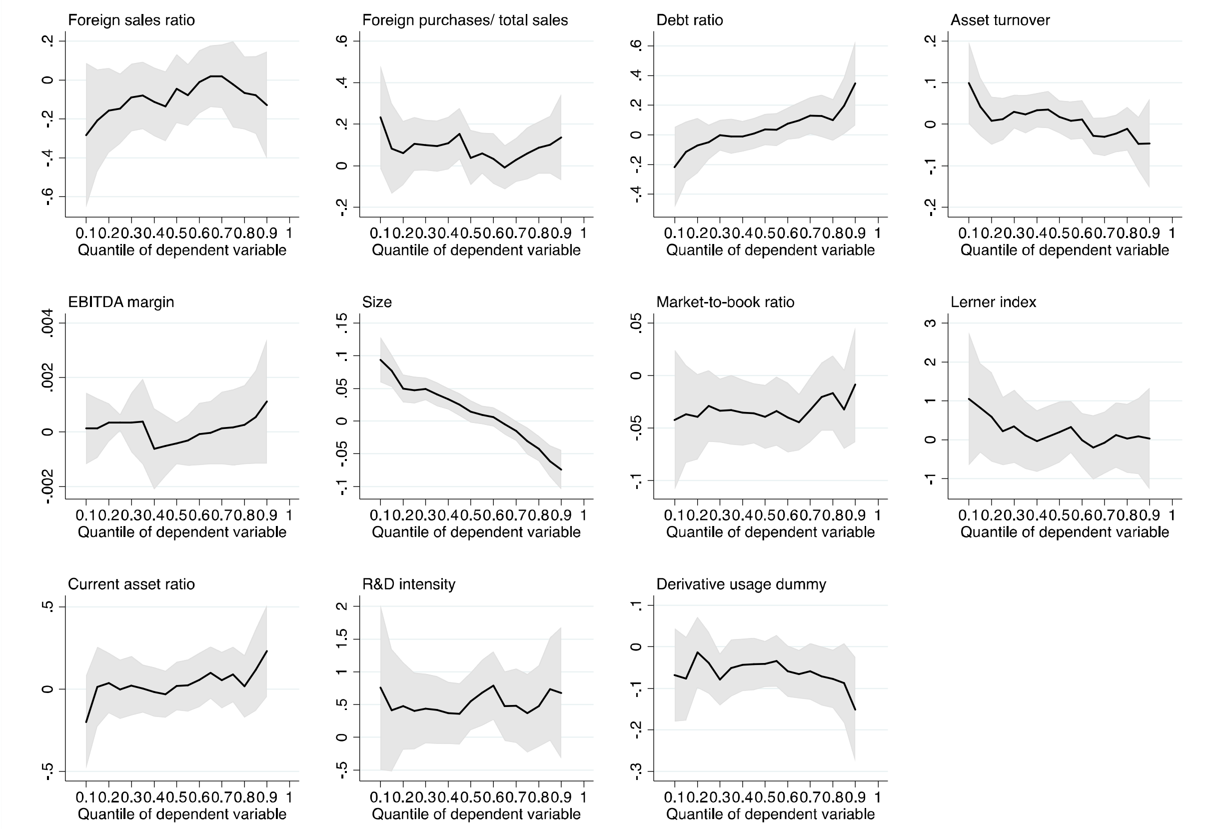
Figure 4
Development of selected firms' exposure over time



This Figure shows the development of the exposure of selected firms over time. Exposures are estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific EMU and ROW exchange rate indices. The returns of the exchange rate indices are standardized.

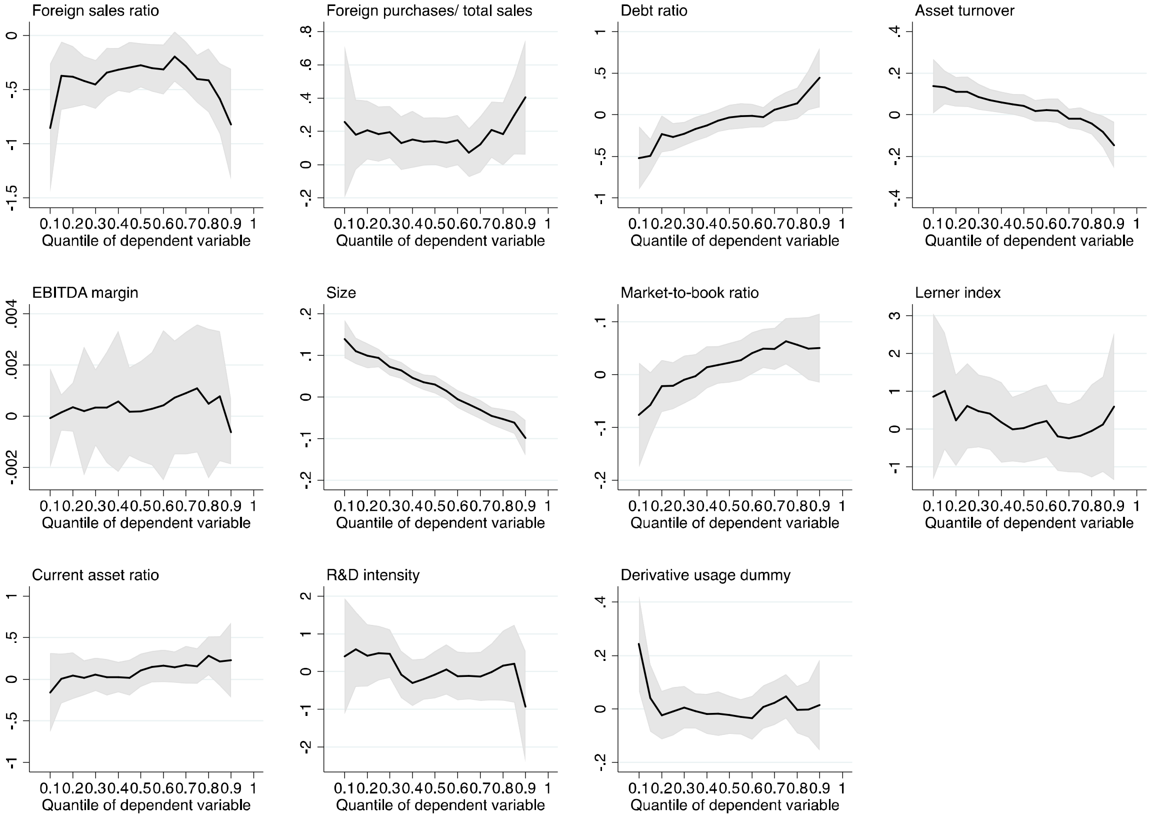
Figure 5

Coefficients over quantiles: EMU exposure



This Figure shows coefficients (solid line) and 90% confidence intervals (shaded area, calculated from robust standard errors bootstrapped from 1,000 replications) of the explanatory variables for unconditional quantiles from the 10% to the 90% quantile of the EMU exposures, estimated from the extended Fama-French model characterized by Equation (2) and using weekly returns with particular trade-weighted industry-specific EMU exchange rate indices. The returns of the exchange rate indices are standardized.

Figure 6
Coefficients over quantiles: ROW exposure



This Figure shows coefficients (solid line) and 90% confidence intervals (shaded area, calculated from robust standard errors bootstrapped from 1,000 replications) of the explanatory variables for unconditional quantiles from the 10% to the 90% quantile of the ROW exposures estimated from the extended Fama-French model characterized by Equation (2) using weekly returns with particular trade-weighted industry-specific ROW exchange rate indices. The returns of the exchange rate indices are standardized.

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