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Foreign Exchange Derivative Use and Firm Value: Evidence from German Non-Financial Firms*

Matthias F. Merkel†

Abstract

In this paper I investigate whether the use of foreign exchange (FX) derivatives adds value to German firms, which together make up one of the major export economies in the world. I analyze a unique, hand-collected dataset that includes information on the use of FX derivatives by 391 firms between 2004 and 2013. After controlling for a set of fundamental firm characteristics I find that on average the use of FX derivatives does significantly add to their value. This relationship seems to be mainly driven by firms with low values, suggesting that such firms can increase their value by using these instruments. Analysis of the detailed information of my dataset shows that besides the simple decision to use derivatives, the intensity of firms' use of them is also positively linked to firm value. My results show that especially firms with high values can further increase their firm value by increasing their FX derivative holdings.

Keywords: FX derivatives, hedging, Tobin's Q, firm value

JEL classification: F23, G15, G32

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1 Introduction

Theoretical literature suggests that the use of derivatives for risk management purposes increases the value of a firm. In particular, Smith and Stulz (1985) show that hedging reduces the expected costs of financial distress and that firms can reduce expected tax liabilities under a convex tax schedule by smoothing taxable income. Leland (1998) argues that hedging may increase a firm's debt capacity, allowing the firm to take advantage of the debt tax shield to add value to the firm. Froot et al. (1993) show that firms may hedge to better match their internal cash flows with their financing needs and thus avoid costly external financing costs.[1] A stream of empirical research has focused on these theories of hedging and examined why firms use derivatives and how this is related to firm risk (e.g., Guay, 1999; Tufano, 1996; Haushalter, 2000; Allayannis and Ofek, 2001; Graham and Rodgers, 2002; Geczy et al., 2007; Bartram et al., 2011). Moreover, in recent years a number of studies have investigated the relationship between derivative use and firm value (e.g., Allayannis and Weston, 2001; Guay and Kothari, 2003; Nelson et al., 2005; Jin and Jorion, 2006; Mackay and Moeller, 2007; Bartram et al., 2011; Allayannis et al., 2012). These studies provide some empirical evidence that the use of derivatives is associated with higher firm value.

My paper adds to this literature. In particular, I investigate whether the use of foreign exchange (FX) derivatives, such as options, futures and forward contracts, adds value to firms. In doing so, I focus on German firms, which make up the largest economy in the European Union. While a number of previous studies have investigated the link between FX derivatives and the

[1] Stulz (1984) and Smith and Stulz (1985) also argue that derivative use may be motivated by agency problems. Hence, rather than benefitting the firm's shareholders, the firm managers may use derivatives to protect themselves, as they may hold (depending on the compensation scheme) a large portfolio of undiversified firm-risk which may prompt them to use derivatives to hedge their own risk.

value of firms from the U.S., I am to the best of my knowledge the first to analyze this relationship for German firms. As Germany is a major worldwide exporter, German firms typically engage in huge trade activities, making them potential users of FX derivatives. Thus, assuming that such a relationship between derivative use and firm value exists, we would expect this relationship to be strong for German firms.

For my analyses I use a unique, hand-collected dataset that includes information on firms FX derivative use from 391 non-financial firms from 2004 to 2013. I indicate FX derivative use by a binary variable that equals 1 if the firm reports the use of derivatives in its annual report, and zero otherwise. After controlling for a set of firm characteristics that have been identified as important determinants of firm value, such as firm size, leverage and growth opportunities (see, e.g., Allayannis and Weston, 2001; Jin and Jorion, 2006; Allayannis et al. 2012), I find strong evidence that, on average, the use of FX derivatives is positively linked to Tobin's Q, my proxy for a firm's value. My findings suggest that firms that use FX derivatives have a higher firm value, which is in line with prior empirical research (see, e.g., Allayannis and Weston, 2001; Graham and Rodgers, 2002; Nelson et al., 2005; Carter et al., 2006; Allayannis et al., 2012). To mitigate concerns regarding endogeneity, I also estimate a treatment effects model. The results remain qualitatively unchanged, implying that the economic relationship between FX derivative use and firm value is quite robust.

Having analyzed the average relationship between FX derivative use and firm value, I next investigate how the use of derivatives is linked to firms with particularly low or high value. While many studies analyze the average links, this paper is, to the best of my knowledge, the first that explicitly focuses on such firms. To do so, I apply unconditional quantile regressions according to Firpo et al. (2009). This approach allows me to analyze the relationship between derivative use and the value of such firms that are located in the tails of the firm value distribution. I find a significantly positive association between FX derivative use and the 10% quantile of the firm value distribution. This finding indicates that the use of FX derivatives significantly adds value to firms that have a low market value. In contrast, I do not find a significant relationship for firms with a high value.

Finally, I make use of the detailed information of my hand-collected data. Because my data set includes information on the notional amount of FX derivatives held by the sample firms, I can also calculate the intensity of their use of FX derivatives, as measured by a firm's notional holding of FX derivatives over its total assets. Thus I can investigate the relationship between the degree to which firms use FX derivatives and firm value. I find a positive and significant association. This finding suggests that – besides the simple decision to use FX derivatives – on average, a higher intensity of FX derivative use also adds value to the firm. When analyzing the firms with high and low market values, and comparing them to the results from regressions with the FX derivative use dummy, I now find a statistically significant link for the 90% quantile – but none for the 10% quantile. This finding suggests that for firms with high market values, a more intense use of FX derivatives is associated with even higher firm valuation.

In a nutshell, my key results can be summarized as follows: Both the use of FX derivatives (dummy) and a higher intensity of FX derivative use are linked to a higher firm value. Moreover, I find that FX derivative use significantly adds value to firms with low firm values, suggesting that these firms may increase their value by the decision to use such instruments. On the other hand, a higher intensity of FX derivative use adds value to firms with high values, indicating that these firms can further increase their value by raising FX derivative holdings.

The remainder of the paper is organized as follows. Section 2 introduces my sample and reports summary statistics. Section 3 describes my empirical strategy and methodology. Section 4 presents the empirical results, including a set of robustness tests. Finally, Section 5 concludes.

2 Sample selection and data

2.1 Sample selection

My sample includes large, stock-listed German firms.[2] I exclude financial institutions as their motives for using derivatives may differ from those of non-financial firms. For the remaining 391 non-financial firms I build a panel data set that includes all firm years between 2004 and 2013. To ensure uniform accounting standards among the firm observations, I only include those years in which the firm was listed in the Prime or General Standard. Finally, I end up with an unbalanced panel of 3,151 firm years. For those firm years I obtain data on firm characteristics from Thomson Reuters Worldscope and hand-collect information on FX derivative use from the annual reports of the companies.[3]

2.2 Firm market value

As is common in empirical research on corporate finance, I use Tobin's Q as a proxy for a firm's market value (e.g., Allayannis and Weston, 2001; Jin and Jorion, 2006; Mackay and Moeller,

[2] To qualify as large firm, it must have both total assets and total sales of more than 50 million euros. Moreover, the firm must be listed in the Prime or General Standard. As firms listed in these indices need to prepare their annual reports in accordance with the International Financial Accounting Standards (IFRS), this limitation provides homogenous accounting standards.

[3] In addition, I also hand-collect information on firms' foreign sales and expenses for research and development from their annual reports.

2007; Bartram et al. 2011; Allayannis et al. 2012). In line with previous studies I calculate Tobin's Q as the ratio of the market value of a firm's equity plus the book value of it's total debt over the book value of it's total assets (see, e.g., Allayannis et al. 2012; Bartram et al. 2011).[4] A huge benefit of using Tobin's Q is that it easily allows firms to be compared directly – in contrast to accounting measures or measures based on stock returns that need to be risk-adjusted or normalized (Allayannis and Weston, 2001; Lang and Stulz, 1994).[5] Panel A of Table 1 presents summary statistics of Tobin's Q and gives a short overview of the firms in my sample.

[Table 1 about here]

Measured by total assets and total sales, the sample includes both small and large companies. However, the sample includes some very large companies, as indicated by the medians being much smaller than the means. Average Tobin's Q is 1.459, while the median is 1.223. This finding implies that the distribution of Q is skewed. Moreover, the 10% and 90% quantile as well as the standard deviation show that Tobin's Q is widely dispersed.

When making use of the time-series dimension of the data, I find that average Tobin's Q is relatively constant, but that it dropped significantly during the financial crisis in 2008. Figure 1 graphically illustrates the development of the yearly means of Tobin's Qs over the sample period.

[Figure 1 about here]

[4] I calculate the market value of equity by multiplying a firm's common shares outstanding with its (fiscal year end) market price. Preferred stocks are treated as common shares (and therefore as equity capital) as in Germany these preferred stocks ("Vorzugsaktie") must have, except for the voting right, the same privileges as ordinary shares.

[5] Allayannis and Weston (2001) examine a variety of alternative proxies for Tobin's Q that are based on the procedures introduced by Lewellen and Badrinath (1997) and Perfect and Wiles (1994), respectively, but find that their results are similar for the different measures of firm value. Therefore, as many of the data needed for these calculations are not available anyway for the firms in my sample, I use the market-to-book ratio in my analyses.

The yearly mean firm values are around 1.459 (the average of Tobin's Q for the entire sample) for any year of the observation period – despite the before-mentioned drop in 2008. However, I also find phases with high cross-sectional variation and extreme values in the tails of the distribution as shown by the 10% and 90% quantiles.

I analyze more deeply these extreme values with regard to their persistence. Doing so, I apply a non-parametric test based on a contingency table approach that compares the values of two consecutive years (see, e.g., Brown and Goetzmann, 1995, and Li, 2005, in the context of performance measurements of financial products). First, I investigate the persistence of low Tobin's Qs by dividing the firm values of each year into two parts, whereby Tobin's Qs below the 10% quantile in the specific year are defined as low market values (*low*) and Tobin's Qs above the 10% quantile as not being low (*nolow*). Then, for each firm, Tobin's Q of the current year is compared with its level of the previous year. If both values are part of the low market value of the yearly distribution they are defined as a *low-low* combination. If a firm's value was low in the previous year (i.e. below the 10% quantile), but is not low in the current year (i.e. above the 10% quantile), the values are defined as a *low-nolow* combination. Analogously, the same is done for *nolow-nolow* and *nolow-low* combinations. Then, from the number of these categories the odds ratio (also referred to as the cross-product ratio) is calculated as:

$$OR = \frac{(low{-}low) \times (nolow{-}nolow)}{(nolow{-}low) \times (low{-}nolow)}. \tag{1}$$

An odds ratio of 1 means that for a low market value now, the market value in the past is not important. Accordingly, an odds ratio of 1 would correspond to the null hypothesis that the firm values of two consecutive years are unrelated to each other.

I also examine the persistence of high firm values, repeating the procedure for large Tobin's Qs, i.e. values above the 90% quantile, and calculate the particular odds ratio.[6] The results are reported in Table 2.

[Table 2 about here]

Overall, I find a high persistence regarding firm value. In particular, the odds ratio for small Qs for two consecutive years is 22.5. This corresponds to a 22.5% higher chance of having a low market value if the market value in the year before was low (below the 10% quantile). The persistence for large Qs (above the 90% quantile) is even higher as suggested by an odds ratio of 112. The results thus suggest that low and high firm values are quite stable.

2.3 Explanatory variables

2.3.1 FX derivative use

I collect by hand the information on firms' use of FX derivatives from their annual reports and classify a firm as a user of FX derivatives for each year that they report use of such instruments. Moreover, I also obtain the year-end notional values of FX derivative holdings of these firms. However, as IFRS do not require firms to report the total national value of derivatives I cannot

[6] Analogously to the procedure for low firm values, I divide the dataset into firm values that are high (above the 90% quantile) and those that are not high (below the 90% quantile) for each year and calculate the odds ratio from the *high-high, nohigh-nohigh, nohigh-high*, and *high-nohigh* combinations according to Equation (1).

gather this information for all firms in my sample. Nevertheless, many firms provide their FX derivative holdings on a voluntarily basis, so that I obtain the notional values for 2,889 of the 3,151 firm years.[7]

Panel B of Table 1 gives an overview of firms' FX derivative use. For 52.7% of the observations, firms report FX derivative use. On average derivative holdings make up 6.1% of firms' total assets. However, the level is widely distributed as indicated by the high standard deviation and the 10% and 90% quantiles.

2.3.2 Control variables

In my analyses I include a set of control variables that have been shown to being significantly related to firm value (see, e.g., Allayannis and Weston, 2001; Jin and Jorion, 2006; Allayannis et al. 2012).

One control variable is *firm size*, measured by the log of total assets, as size has been shown to be linked to a firm's value. On the one hand, larger firms might benefit from economies of scale, from more efficient risk management or from risk reductions due to product and client diversification leading to a higher accounting profitability and to greater efficiency (see Peltzman, 1977; Mueller, 1987; Lang and Stulz, 1994). Logically therefore, firm size should be positively related to firm value. On the other hand however, larger firms might be less flexible in reacting to operational changes, so that size may also be negatively linked to value. In addition, in larger firms, mangers are more likely to derive private benefits, e.g. through increased power and prestige or through compensation arrangements that are typically greater in larger companies, so

[7] The notional values of foreign exchange derivatives include FX forward contracts, FX futures and FX options. Following existing literature I do not include FX swaps, as they are primary used to change foreign debt into liabilities denominated in domestic currency (Allayannis and Ofek, 2001; Beber and Fabbri, 2012).

that firm size might involve costs in the relationship between managers and shareholders leading to a discount in firm value (see Denis et al., 2002). Empirical evidence on the relationship between firm size and firm value is ambiguous, documenting both positive (e.g., Fauver et al., 2004; Wu, 2011) and negative links (e.g., Pramborg, 2004; Ammanna et al. 2011).

To control for the financial condition I include the *quick ratio*, defined as cash and marketable securities over current liabilities. Firms that are able to pay their short-term operating liabilities with (almost) readily available cash are less exposed to cash-flow volatility and hence to financial distress. Accordingly, they should have a higher firm value so that the quick ratio should be positively related to it (e.g. Ammanna et al. 2011; Connelly et al., 2012).

Moreover, I include the *debt ratio*, measured by total debt over total assets, to control for the relationship between leverage and firm value. Based on the capital structure irrelevance theorem of Modigliani and Miller (1958) and Miller and Modigliani (1961), a number of theoretical studies have argued that due to the existence of market imperfections the capital structure of a firm may be linked to its value.[8] The literature disagrees regarding the effect of debt on firm value. On the one hand, debt financing may force firm managers to pay out funds with the result that the firm has fewer funds available that might otherwise be wasted in negative net present value projects. Hence, leverage might reduce the overinvestment problem, leading to higher firm value (see Jensen, 1986; Stulz, 1990). On the other hand, debt financing may deter firm managers from investing in positive net present value projects, if the benefits from the project mainly belong to the creditors and not to the shareholders. Correspondingly, leverage may increase the underinvestment problem, leading to a decrease in firm value (see Myers, 1977). Empirical

[8] In particular, Modigliani and Miller (1958) and Miller and Modigliani (1961) argue that the capital structure does not affect firm value in a perfect market.

evidence on the effect of leverage on firm value is mixed: some studies find that leverage serves to increase value (e.g. McConnell and Servaes, 1995), while others find the reverse (e.g. Konjin et al., 2011).

Furthermore, I control for a firm's access to financial markets, as firms might waive investments or projects if they do not get the necessary financing. Following Lang and Stulz (1994) and Servaes (1996) firms that have difficulties in raising funds (i.e. firms that are constrained for capital) are more likely to invest in positive net present value projects as these firms need to budget their funds carefully. Such net present value projects should result in a higher firm value. Hence, financial constraints should increase firm value. In line with previous literature, I control for a firm's financial constraints by including a dummy that equals 1 if the firm pays a *dividend* in the current year, and zero otherwise. Firms that pay a dividend can generally more easily cut or reduce their dividend payments to finance investments and projects and are hence less likely to be financially constrained. Accordingly, the dividend dummy should be negatively related to Tobin's Q (see Fazzari et al., 1988).[9] However, there are also some theories arguing that firms that pay a dividend are worth more (e.g. Gordon, 1963; Walter, 1963; Bhattacharya, 1979; John and Williams, 1985), so that overall the relationship between the dividend dummy and firm value is ambiguous.[10]

[9] It should be noted that the dividend dummy is rather a poor proxy for financing constraints. More recently, many studies use the Kaplan and Zingales (1997) index instead (e.g. Allayannis et al, 2012). However, the parameters for calculating the Kaplan and Zingales (1997) index are derived from U.S. firms. Moreover, many of the required firm characteristics needed to calculate the index are not available for the firms in my sample. Hence, I rely on the dividend dummy as proxy for financial constraints in my analysis.

[10] In particular, from an investor's perspective, the certainty of a current dividend may be preferred over possible, uncertain future gains (that might arise from using the dividend payment for financing projects) and hence an investor may pay a higher price to a dividend-paying firm, resulting in the value of this firm being higher (Gordon, 1963; Walter, 1963). Furthermore, firm managers may use dividends to inform the market about the healthiness of the firm so that the payment of a dividend may signal that a firm expects to have higher cash flows in the future and is thus of higher value (Bhattacharya, 1979; John and Williams, 1985).

Following Allayannis and Weston (2001), I include *return on assets (ROA)*, defined as EBITDA over total assets, as a measure of profitability. As profitable firms are more likely to trade at a premium than less profitable firms, ROA should be positively linked to firm value.

Furthermore, I control for a firm's future investment opportunity, which should also be positively related to firm value (see Myers, 1977; Smith and Watts, 1992). Therefore, I include the ratio of *capital expenditures over total sales* as a proxy for growth options in a firm's investment opportunity (see Servaes, 1996; Yermack, 1996). In addition, I also include the ratio of research and development expenditures over total sales *(R&D intensity)* as a proxy for investment growth.[11] This measure can also be used as a proxy for a firm's intangible assets of technological know-how and expertise, which should also add value to the firm (see Morck and Yeung, 1991).

Moreover, I control for a firm's *industrial diversification*. On the one hand, diversification among different industry segments might increase value because such firms might be less prone to risk if they are diversified with regard to customers and products (e.g. Lewellen, 1971; Williamson, 1970). On the other hand, industrial diversification might entail agency costs, as firm mangers could privately benefit from industrial diversification through personal risk reduction (as it reduces the risk of the manger's undiversified portfolio) as well as through increased power and prestige or compensation arrangements (as already mentioned in the context of firm size). Accordingly, diversification might result in a diminution in firm value (see Denis et al., 2002). Indeed, most of the empirical evidence shows that diversification among industries destroys value (e.g. Lang and Stulz, 1994; Berger and Ofek, 1995; Servaes, 1996; Bodnar et al,

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

1999; Lins and Servaes, 1999; Denis et al., 2002). In line with previous research, I control for these effects by setting a dummy that equals 1 if the company operates in more than one industry segment (measures at the four-digit SIC code) and zero otherwise.

Likewise, I control for *geographic diversification* by including a dummy variable that equals 1 if the firm reports foreign sales in the current year. Following prior research, internationality should increase value, e.g. by economies of scale, synergy effects or increased operational flexibility (see Morck and Yeung, 1991; Kim and Mathur, 2008). However, there are also some arguments that multinationality might reduce firm value due to additional costs from operational, political, environmental and cultural challenges that arise when operating abroad (see Bodnar et al., 1999; Eckert et al., 2010). Moreover, firm managers might benefit from global diversification in the same way as they benefit from industrial diversification, but these might also lead to agency costs and hence to a lower firm value. Empirical evidence on the relationship between internationalization and firm value is mixed; positive links are found (e.g. Morck and Yeung, 1991; Riahi-Belkaoui, 1998; Bodnar et al., 1999; Eckert et al., 2010) as well as negative ones (e.g. Christophe, 1997; Denis et al., 2002; Fauver et al., 2004).

Finally, I include the log of average *industry Q* (calculated by the yearly average Tobin's Q of the industry a firm belongs to) to control for industry effects.[12] Following prior studies, firms that belong to an industry with high average Qs should have higher values (Doidge et al., 2004; Allayannis et al., 2012).

Panel C of Table 1 presents summary statistics of the variables included in these analyses. The majority of firms are diversified across several industries (75.9%) and active on the foreign

[12] It should be noted that the use of the average industry Q might give rise to endogeneity concerns. However, repeating the regression without the mentioned variable produces results that are practically identical. Moreover, the variable is only included to control for possible industry effects and the estimated relationship is not of primary interest in my analysis.

market (91.6%). Moreover, my average firm has a quick ratio of 4.787 and a debt ratio of 57.8%. Table 3 shows pairwise correlations of the explanatory variables. While most of the variables are correlated at low levels, I find sizeable correlations between FX derivative use and firm size, suggesting that large firms are more likely using FX derivatives. However, the correlation between the variables is still below a relevant level.

3 Empirical setup

I investigate how firms' use of FX derivatives is linked to firm value. First, I analyze the average relationships. Doing so, I apply between-effects and Fama-MacBeth (1973) regression to analyze the cross-sectional variation as well as pooled OLS and industry fixed-effects regression to control for unobservable characteristics on an industry-level that may affect firm value.[13] In line with previous studies, I use the natural log of Tobin's Q, as the distribution of Q is skewed as already noted above (e.g., Allayannis and Weston, 2001; Allayannis et al., 2012). To indicate if a firm uses FX derivatives, I use a binary variable that equals 1 if the firm discloses derivative use in a particular year, and zero otherwise. The basic regression appears as follows:

$$Q_{i,T} = \alpha + \beta_{FXD}\, FXD_{i,T} + \sum_{n=1}^{N} \beta_n\, FirmCh_{n,i,T} + \varepsilon_{i,T}\ , \qquad (2)$$

where $Q_{i,T}$ is the log of Tobin's Q, as my proxy for the market value of firm *i* in year *T*, $FXD_{i,T}$ is the dummy variable indicating whether firm *i* uses FX derivatives in year *T*, and $FirmCh_{n,i,T}$ is the firm-specific control variable *n* of firm *i* for year *T*.

[13] I group firms into 17 industry sectors, based on their two-digit SIC codes.

However, it might be that firms that use FX derivatives are systematically different from firms that do not use such instruments in a way that is linked to firm value (e.g. Fauver and Naranjo, 2010). For example, firms with a high value might use derivatives since it is easier for them to implement a risk management division that is needed to efficiently trade derivatives compared to firms with a low value. To mitigate concerns regarding such possible self-selection, I estimate a treatment effects model that is frequently used in the corporate finance literature to address such (as well as other) endogeneity problems (see, e.g., Villalonga and Amit, 2006; Miller et al., 2007).

To do so, I model a firm's decision to use derivatives (the treatment) as a function of variables that have been identified as being important factors for FX derivative use in previous studies. Then, the predicted values of the decision to use derivatives are used to estimate its relationship to firm value. More formally, I fit the model (see Maddala, 1983; Greene, 2012):

$$Q_{i,T} = \alpha + \beta_{FXD}\, FXD_{i,T} + \sum_{n=1}^{N} \beta_n\ FirmCh_{n,i,T} + \varepsilon_{i,T}\,, \tag{3}$$

where $FXD_{i,T}$ is a binary decision variable indicating whether the treatment (FX derivative use) is assigned or not. The decision to obtain the treatment $FXD_{i,T}$ is modeled as the outcome of an unobserved latent variable $FXD^*_{i,T}$ that is a linear function of the exogenous covariates $w'_{i,T}$ and a random component $u_{i,T}$. Specifically,

$$FXD^*_{i,T} = \beta\, w'_{i,T} + u_{i,T}\,, \tag{4}$$

and the observed decision is:

$$FXD_{i,T} = \begin{cases} 1, \ if \ FXD^*_{i,T} > 0 \\ 0, \ otherwise \end{cases} \quad . \tag{5}$$

$w'_{i,T}$ is a vector of variables that have previously been shown to determine a firm's decision to use FX derivatives. In particular, I use foreign business activity, firm size, growth opportunities, leverage and liquidity (see Geczy et al., 1997; Allayannis and Ofek, 2001; Graham and Rodgers, 2002; Bartram et al., 2009).[14] I estimate the model in one step using the maximum likelihood approach, with and without industry fixed-effects, respectively. I also estimate the model in a two-step procedure (Heckman, 1979) and obtain similar results. This is why the incidental parameter problem (e.g. Lancaster, 2000) in an ML with fixed-effects is not an issue here.[15]

As already reported above, my sample involves firms with particularly high and low Tobin's Qs. I more deeply investigate these firms by applying unconditional quantile regressions developed by Firpo et al. (2009) to Equation (2).[16] In contrast to the regressions from above, which show the average relationships between firm value and FX derivative use (and the other explanatory variables), this approach allows me to investigate how an unconditional quantile of the pooled Tobin's Q distribution is related to derivative use (and the other explanatory variables). As the estimated coefficients may differ between the different quantiles, the relationship between the explanatory variable including FX derivative use and firm value may be different for firms with high and low value. Again I estimate the coefficients for the pooled panel

[14] Foreign business activity is proxied by a firm's foreign sales over its total sales (e.g. Beber and Fabbri, 2012).
[15] For the sake of brevity I do not report these results here, but they are available upon request.
[16] I am deeply grateful to Nicole Fortin for providing the STATA ado-file on her homepage.

and with industry fixed-effects. Moreover, I calculate robust standard errors bootstrapped from 1,000 replications.

Finally, I investigate the relationship between the degree to which firms use FX derivatives and firm value, by using the notional amounts of FX derivative holdings scaled by total assets, – referred to here as the FX derivative ratio – instead of the simple FX derivative use dummy.[17] Again, I apply the different kinds of regressions already discussed above. Moreover, I repeat these regressions for a reduced sample including only those firm years in which FX derivative use is reported.

4 Empirical results

4.1 The use of FX derivatives and firm value

I start with analyzing the average relationship between FX derivative use and firm value. Table 4 presents the results of applying between-effects, Fama-MacBeth (1973), pooled OLS and industry fixed-effects regression according to Equation (2).

[Table 4 about here]

The coefficient on the FX derivative use dummy is positive and significant (except for the between-effects regression). This finding suggests that the use of FX derivatives is associated with higher firm value, which is in line with prior research (e.g., Allayannis and Weston, 2001; Mackay and Moeller, 2007; Bartram et al., 2011; Allayannis et al., 2012). In particular, I find that

[17] Scaling notional amounts of derivative holdings by total assets is common in corporate risk management literature (e.g., Knopf et al., 2002; Beber and Fabbri, 2012; Graham and Rodgers, 2002).

on average firms that use FX derivatives are valued about 4.4% higher than firms that do not use such instruments (as we use the log of Tobin's Q, the estimated coefficient of 0.043 in the fixed-effects regression corresponds to a 4.4% premium). The size of the premium is in line with Allayannis and Weston (2001), Graham and Rodgers (2002), Nelson et al. (2005), Carter et al. (2006) and Allayannis et al. (2012).

I also find statistically significant relationships for many of the control variables. In particular, I find that firm size is negatively related to firm value, suggesting that larger firms are associated with lower values (see Lang and Stulz, 1994). As expected, the link for the quick ratio is positive, indicating that higher liquidity is associated with higher firm value. Moreover, my findings show that the debt ratio is positively linked to firm value, suggesting that higher leverage increases firm value. I also find a significantly positive sign on the dividend dummy, indicating that dividend-paying firms have higher value. Consequently, this finding does not lend empirical evidence to the theory that firms that are constrained for capital are valued higher because they are more likely to invest in positive net present value projects (Lang and Stulz, 1994; Servaes, 1996). However, as already mentioned, the dividend dummy is rather a weak proxy for financial constraints.

As expected, I find a positive relationship between firm value and ROA and R&D expenses, respectively, suggesting that firms with a higher profitability and more investment opportunities are valued higher. The coefficient on industrial diversification is also positive (except for between-effects regression) and shows that diversification among different industries adds value to the firm, which is in line with the theoretical arguments of Williamson (1970) and Lewellen (1971). In contrast, though not statistically significant, geographical diversification is negatively linked with firm value. Finally, and obviously expected, I find a strongly positive link for the average industry Q showing that firms that belong to industries with a high average Q have higher values.[18]

To address potential endogeneity concerns, I next apply a treatment effects model.[19] Table 5 presents the results.

[Table 5 about here]

Generally, the results are similar to those reported above. Most interestingly and of primary concern, the coefficient on the FX derivative use dummy is again positive and significant**.** Hence, the results from the treatment effects model confirm the significantly positive link between FX derivative use and firm value.

Summarizing, my key findings so far indicate that the use of FX derivatives on average adds value to the firm. This is in line with risk management theories (e.g., Smith and Stulz, 1985; Bessembinder, 1991; Froot et al., 1993; Leland, 1998) and prior studies on this issue (e.g., Allayannis and Weston, 2001; Mackay and Moeller, 2007; Bartram et al., 2011; Allayannis et al., 2012).

4.2 The use of FX derivatives and firm value for high- and low-value firms

Next, I analyze if the documented average relationship between FX derivative use and firm value is also applicable for firms with high or low firm values or if the value of these firms are

[18] As already mentioned, the average industry Q is included to control for possible industry effects and the estimated relationship is not of primary interest in my analysis. When repeating the regressions without the average industry Q the results for the remaining variables are quite similar to those reported above (these results are not tabulated here, but available from the author upon request).

[19] Of course, the treatment effects model cannot address or rule out all potential endogeneity concerns. Hence, this test should be viewed as a suggestive rather than an ultimate check of robustness.

differentially linked to the use of FX derivatives. Therefore, I apply unconditional quantile regressions to Equation (2) and analyze how the use of FX derivatives is related to the specific quantiles of Tobin's Q's distribution. As the estimated coefficients of the explanatory variables may differ in sign, magnitude and significance between the different quantiles, their relationship with firm value may be different throughout the outcome distribution. To illustrate this, I start with a graphical overview of the results for the entire distribution. Figure 2 presents the estimated coefficients of the explanatory variables- including their 90%-confidence interval, for quantiles between 10% and 90%.

[Figure 2 about here]

The results illustrate the different relationships that may emerge for the different quantiles. For example, the coefficient on the R&D intensity (R&D expenses over total sales) is small for the 10%, 20%, and 30% quantile, respectively (about 0.3), suggesting that the relationship between the R&D intensity and firm value is quite small for firms with low values. However, the coefficient increases with increasing quantiles and is large for the 80% and 90% quantile, respectively (above 2.0), indicating a sizeable relationship for firms with a high firm value.

For the debt ratio and industrial diversification, the different relationships between the different quantiles are even more striking: for debt ratio the relationship is positive for the 10% to 60% quantiles and negative for the 70%, 80%, and 90% quantile, respectively. Hence, this finding suggests an asymmetric relationship with firm value when applied to firms with low or high values. For industrial diversification the links are reversed. In particular, the coefficient is (slightly) negative for the 10% and 20% quantiles, respectively, and positive for the 80% and 90% quantile, respectively.

For the FX derivative use dummy, the coefficient is positive over all quantiles, corroborating the positive relationship between the use of such instruments and firm value. However, the coefficient slightly moves between the quantiles. Moreover, the confidence interval is much broader for the high quantiles compared to small quantiles. To analyze this finding further, I take a closer look on the regression results. As already mentioned, I am particularly interested in how the use of FX derivatives is linked to high and low Tobin's Qs. I therefore focus on the 10% and 90% quantile of the distribution. Table 7 presents the results of applying unconditional quantile regression for the pooled panel (Columns (1) and (3)) and with industry fixed-effects (Columns (2) and (4)). In particular, the estimated coefficients for the 10% quantile (90% quantile) show how the 10% quantile (90% quantile) is linked to the explanatory variables.

[Table 6 about here]

The results show, as already noted above, that FX derivative use is positively linked to firm value for both tails of Tobin's Q distribution, indicating that the use of derivatives shifts the particular quantile of the firm value distribution. For the 10% quantile the coefficient is strongly significant. Hence, this relationship suggests that the use of FX derivatives is associated with a higher valuation for firms with low firm values. The premium (4.5% in the fixed-effects model) is in line with the premium estimated in the (fixed-effects) OLS regression. For the 90% quantile the coefficient is also positive, but statistically not significant. Hence, my findings suggest that the average positive relationship between FX derivative use and firm value documented in the last section is mainly driven by low-value firms.

Moreover, I find that most of the significant control variables documented in the regressions analyzing the average relationships, are also significantly linked to low and high firm values. In particular, firm size is negatively related to the value of firms with high Tobin's Qs (90% quantile). This finding suggests that for firms with high values, larger firm size is associated with lower firm values. In contrast, for the 10% quantile, the coefficient is slightly positive suggesting that an increase in size is associated with higher firm values for low-value firms. However, the relationship is statistically not significant.

Like for the average relationship, the link for the quick ratio is positive and quite small for both firms with low and high values, but the link is statistically not significant. For the debt ratio, I find, as already intimated above, an asymmetric relationship with Tobin's Q for the 10% and the 90% quantile. In particular, for the 10% quantile the coefficient is positive, while it is negative for the 90% quantile. Hence, the results indicate that for firms with low Tobin's Qs, higher leverage is associated with a higher valuation. In contrast, for firms with high Tobin's Qs, a higher debt ratio is associated with lower firm values. However, the relationship for the latter is not statistically significant.

The coefficients for the dividend dummy, ROA and R&D intensity are significantly positive for both the 10% and 90% quantile, suggesting that dividend payment as well as higher levels in the remaining variables are linked to higher firm values for both firms with large and small Tobin's Qs. Hence, these findings confirm that the average relationships documented above also apply for low- and high-value firms. However, the coefficients on ROA and the R&D intensity are considerably larger for the 90% quantile than for the 10% quantile. This suggests that with regard to firm valuation, especially firms with high values benefit from higher profitability and research intensity.

As already mentioned, the relationship for industrial diversification is asymmetric. For firms with low value, diversification among different industry segments is associated with lower firm value. In contrast, for firms with a high market value, the link is positive, suggesting that industrial diversification adds value to the firm. Moreover, I again find a statistically positive link for the average industry Q.

4.3 The degree of FX derivative use and firm value

In a final step, I investigate how the degree to which firms use FX derivatives is linked to firm value. To do so, I use the FX derivative ratio (calculated by the notional FX derivative holdings over total assets) as a measure of the intensity of FX derivative use. As already mentioned, I do not obtain information on the notional amounts of FX derivative holdings for all firms in my sample; in fact, my sample for this aspect reduces by about 10%. However, this reduction in sample size is far less dramatic than that reported by other studies.[20] Again here, I apply all regressions discussed above, though for the sake of brevity, I only report the results from industry fixed-effects and unconditional quantile regressions (also with fixed-effects).[21] Table 7 shows the results.

[Table 7 about here]

When analyzing the average relationships (fixed-effects regression shown in Column (1)), the coefficient on the FX derivative ratio is positive and significant, suggesting that higher FX derivative holdings (scaled by total assets) are associated with higher firm value. Indeed, the

[20] See, e.g., Allayannis and Weston (2001) who report that using the notional amount of FX derivative holdings would decrease their sample size by about 39%.

[21] The results from between-effects, Fama-MacBeth (1973) and pooled OLS are quite similar to those reported in Table 7 and available from the author upon request.

results add to the findings from above and show that, not just the decision to use FX derivatives, but also a higher intensity of FX derivative use adds value to the firm.

Again, I apply unconditional quantile regressions to analyze low and high Tobin's Qs. The results for the 10% and the 90% quantile are reported in Columns (2) and (3). I find a positive relationship between the FX derivative ratio and firm value for both low- and high-value firms, suggesting that a higher intensity of FX derivative use is associated with a higher firm valuation for firms with both low and high values. For the 90% quantile the coefficient is statistically significant at the 5% level, suggesting a strong relationship for firms with high Tobin's Qs. Hence, my finding indicates that especially firms with high values benefit from a higher intensity of FX derivative use, which adds value to the firm. Moreover, most of the links between the control variables and Tobin's Q are similar to those reported above and hence corroborate the identified relationships with firm value.

Finally, I repeat the regressions using only the firm years in which firms report FX derivative use. The sample for this is thus reduces to 1,399 observations.[22] The results are similar to those reported above (not tabulated, but available from the author upon request). Again, I find strong evidence that the intensity of FX derivative use is associated with higher firm value, on average and for high-value firms, corroborating my findings.[23]

[22] Although such selection based on the independent variable produces a non-random sample, OLS generates unbiased and consistent estimators of the parameters (see Wooldridge, 2015).

[23] Obviously, endogeneity concerns cannot be fully ruled out here.

4.4 Robustness

I perform a number of additional tests to check the robustness of my results. First repeat my regressions using a sample that includes firms that have foreign sales in a particular year.[24] The underlying idea here is that because of their foreign activity these firms are especially likely to, face (ex-ante) exposure to foreign exchange rate risk and may therefore have a special incentive to use derivatives for hedging purposes (see Allayannis et al., 2012). For this reason, I analyze them separately and find similar results to those reported above.

Second, I use an alternate measure for firm value. As noted above, the average industry Q, i.e. the yearly average Tobin's Q of the industry a firm belongs to, is highly significant in all regressions. Hence, belonging to a specific industry is strongly linked to the value of a firm, and the relationships between its value and use of FX derivatives described above may not be measured correctly. Following Allayannis and Weston (2001) I calculate a primary industry-adjusted Tobin's Q for each firm. This means that for each industry segment (measured at the primary four-digit SIC code) I work out the yearly median Q from all firms that belong to this industry. I then subtract this yearly median Q from the firm's real Q and obtain a "pure" Q that reflects the firm's Q minus the industry effects. Repeating the regressions mentioned above, the results remain qualitatively unchanged.

Finally, I normalize the notional amount of FX derivatives by total sales (rather than by total assets) and re-estimate the regressions using this alternative measure of the intensity of FX derivative use as the dependent variable. Again, I obtain results similar to those reported above.

[24] The reduction in sample size is quite small, as most of the firms in my sample report foreign sales, illustrating the high foreign trade activity of German firms. Specifically, my reduced sample comprises 364 firms and 2,909 firm year observations.

5 Conclusion

In this paper, I analyze the relationship between corporate FX derivative use and firm value, based on a hand-collected dataset of German firms that includes information on firms' use of FX derivatives. After controlling for a set of firm characteristics that have been identified as important for a firm's value, I find strong evidence that on average the use of FX derivatives adds value to a firm, a finding in line with existing empirical research in this field (see, e.g., Allayannis and Weston, 2001; Graham and Rodgers, 2002; Nelson et al., 2005; Carter et al., 2006; Allayannis et al., 2012).

Besides analyzing the average relationships, I focus especially on firms with low and high firm values and examine how their value is linked to the use of FX derivatives. In particular, I apply unconditional quantile regressions to analyze the relationship between FX derivative use and the value of such firms. I find a significantly positive link for low-value firms, suggesting that the use of such instruments adds value to firms with low values. Accordingly, this finding indicates that especially these firms benefit from the use of FX derivatives.

Finally, I investigate how the intensity of firms' FX derivative use, measured by their notional FX derivative holdings over total assets, is related to firm value. Again, I find a positive and significant relationship indicating that, on average, a higher intensity of FX derivative use adds value to the firm. This relationship is strongly significant for firms with high values, indicating that especially these can further increase their firm value by raising FX derivative holdings.

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Table 1
Summary statistics

	No. Obs.	Mean	Median	10% quantile	90% quantile	Std. dev.
Panel A						
Tobin's Q	3,151	1.459	1.223	0.890	2.273	0.819
Total assets (millions)	3,151	5,625.42	254.29	55.59	7,719.60	22,972.97
Total sales (millions)	3,151	4,283.68	299.71	54.98	7,466.40	14,906.06
Panel B						
FX derivative use	3,151	0.527	1.000	0.000	1.000	0.499
FX derivatives ratio: Notional FX derivatives/ total assets	2,889	0.061	0.000	0.000	0.195	0.129
Panel C						
Size (log of total assets)	3,151	12.968	12.446	10.926	15.859	1.960
Quick ratio	3,151	4.787	1.007	0.473	2.357	106.559
Debt ratio	3,151	0.578	0.587	0.300	0.812	0.226
Dividend dummy	3,151	0.624	1.000	0.000	1.000	0.484
Return on assets	3,151	0.108	0.111	0.016	0.218	0.153
Capital expenditures/ sales	3,151	0.050	0.031	0.007	0.098	0.079
R&D/ sales	3,151	0.031	0.007	0.000	0.095	0.053
Industrial diversification	3,151	0.759	1.000	0.000	1.000	0.427
Geographic diversification	3,151	0.916	1.000	1.000	1.000	0.277
Industry Q (log)	3,151	0.281	0.295	0.110	0.430	0.136

This Table reports summary statistics of the variables and selected firm characteristics.

Table 2
Persistence of Tobin's Q

	No. Obs.	Odds Ratio	Z-statistic
Small Tobin's Q (below 10% quantile)	2,759	22.506	20.471
Large Tobin's Q (above 90% quantile)	2,759	112.038	25.054

This Table reports the odds ratio of two consecutive Tobin's Q according to Equation (1). The Z-statistic is calculated according to Brown and Goetzmann (1995).

Table 3

Correlation between the explanatory variables

	FX derivative use	Size	Quick ratio	Debt ratio	Dividend dummy	Return on assets	Capital expenditures/ sales	R&D/ sales	Ind. divers.	Geog. divers.	Industry Q
FX derivative use	1.000										
Size	0.506	1.000									
Quick ratio	-0.036	-0.021	1.000								
Debt ratio	0.100	0.173	-0.087	1.000							
Dividend dummy	0.230	0.383	0.025	-0.174	1.000						
Return on assets	0.013	0.040	0.029	-0.233	0.267	1.000					
Capital expenditures/ sales	-0.006	0.115	-0.019	-0.022	0.011	0.016	1.000				
R&D / sales	0.058	-0.056	-0.016	-0.194	-0.041	-0.035	-0.008	1.000			
Industrial diversification	0.162	0.173	0.017	0.125	0.051	0.049	0.020	-0.140	1.000		
Geographic diversification	0.276	0.058	-0.106	0.052	0.016	-0.006	-0.012	0.172	0.192	1.000	
Industry Q	-0.117	-0.076	0.000	-0.061	0.009	0.076	-0.032	0.118	-0.081	-0.005	1.000

This Table reports Pearson correlation coefficients between the explanatory variables.

Table 4

Tobin's Q, FX derivative use and firm characteristics: standard panel regressions

Variable name	Between-effects regression (1)	Fama-MacBeth regression (2)	Pooled OLS regression (3)	Fixed-effects regression (4)
FX derivative use (dummy)	0.058	0.038*	0.037**	0.043*
	(1.194)	(2.078)	(2.198)	(1.937)
Size	-0.014	-0.017***	-0.018***	-0.022*
	(-1.215)	(-3.357)	(-4.656)	(-1.772)
Quick ratio	0.001**	0.004**	0.000***	0.000***
	(2.396)	(2.881)	(4.599)	(8.706)
Debt ratio	0.170*	0.157	0.140***	0.138
	(1.928)	(1.234)	(2.772)	(1.626)
Dividend	0.096*	0.112**	0.123***	0.126***
	(1.943)	(2.541)	(6.806)	(4.711)
Return on assets	1.294***	0.810***	0.545***	0.546**
	(6.805)	(6.063)	(4.296)	(2.721)
Capital expenditures / sales	0.088	-0.205	-0.093	-0.086
	(0.334)	(-1.433)	(-0.995)	(-0.572)
R&D / sales	1.671***	1.207***	1.254***	1.373***
	(5.047)	(6.791)	(8.031)	(5.501)
Industrial diversification	-0.002	0.027**	0.030*	0.028
	(-0.055)	(2.810)	(1.885)	(0.444)
Geographic diversification	-0.028	-0.019	-0.042	-0.024
	(-0.426)	(-1.787)	(-1.610)	(-0.215)
Industry Q (log)	0.933***	0.805***	0.876***	0.943***
	(5.370)	(45.226)	(14.744)	(20.906)
Intercept	-0.184	-0.036	0.017	0.024
	(-0.921)	(-0.430)	(0.291)	(0.165)
Observations	3151	3151	3151	3151
R-squared	0.322	0.231	0.205	0.167

This Table reports results from between-effects, Fama-MacBeth (1973), pooled OLS, and industry fixed-effects regression using Tobin's Q as the dependent variable and a set of firm characteristics as explanatory variables. T-statistics are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using conventional (1), Newey-West (2), robust (3) and cluster-robust (4) standard errors, respectively.

Table 5
Tobin's Q, FX derivative use and firm characteristics: treatment effects model

	All	
	Pooled	Fixed-effects
Variable name	(1)	(2)
FX derivative use (dummy)	0.077** (2.491)	0.109* (1.927)
Size	-0.023*** (-4.779)	-0.031** (-2.055)
Quick ratio	0.000*** (4.612)	0.000*** (8.804)
Debt ratio	0.139*** (2.738)	0.135 (1.601)
Dividend	0.124*** (6.856)	0.127*** (4.803)
Return on assets	0.546*** (4.319)	0.545*** (2.749)
Capital expenditures / sales	-0.091 (-0.974)	-0.080 (-0.538)
R&D / sales	1.226*** (7.803)	1.337*** (5.301)
Industrial diversification	0.028* (1.814)	0.027 (0.434)
Geographic diversification	-0.051* (-1.892)	-0.035 (-0.320)
Industry Q (log)	0.882*** (14.937)	0.948*** (19.988)
Intercept	0.071 (1.068)	0.119 (0.805)
Observations	3151	3151
R-squared	0.206	0.169

This Table reports results from a treatment effects model using maximum likelihood estimation procedure with and without industry fixed-effects using Tobin's Q the as dependent variable and a set of firm characteristics as explanatory variables. Z-statistics are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using robust (1) and cluster-robust (2) standard errors, respectively.

Table 6

Tobin's Q, FX derivative use and firm characteristics: unconditional quantile regressions

	10% quantile		**90% quantile**	
	Pooled	Fixed-effects	Pooled	Fixed-effects
Variable name	(1)	(2)	(3)	(4)
FX derivative use (dummy)	0.046**	0.044**	0.021	0.045
	(2.516)	(2.233)	(0.377)	(0.794)
Size	0.002	0.001	-0.058***	-0.061***
	(0.362)	(0.111)	(-3.911)	(-3.603)
Quick ratio	0.000	0.000	0.001	0.001
	(0.252)	(0.204)	(0.358)	(0.328)
Debt ratio	0.480***	0.474***	-0.150	-0.126
	(7.962)	(7.467)	(-0.753)	(-0.649)
Dividend	0.104***	0.113***	0.184***	0.183***
	(4.659)	(4.922)	(3.139)	(3.120)
Return on assets	0.341***	0.338***	1.319***	1.321***
	(4.128)	(4.295)	(3.601)	(3.820)
Capital expenditures / sales	-0.051	-0.073	-0.122	-0.015
	(-0.488)	(-0.669)	(-0.548)	(-0.068)
R&D / sales	0.447***	0.325**	3.274***	3.794***
	(2.968)	(2.180)	(4.529)	(5.027)
Industrial diversification	-0.024	-0.027	0.184***	0.185***
	(-1.322)	(-1.510)	(2.991)	(3.001)
Geographic diversification	-0.010	0.004	-0.113	-0.124
	(-0.316)	(0.124)	(-1.311)	(-1.183)
Industry Q (log)	0.539***	0.652***	1.575***	1.384***
	(6.108)	(4.435)	(6.634)	(3.542)
Intercept	-0.644***	-0.629***	0.794***	0.534**
	(-8.845)	(-5.919)	(4.095)	(2.231)
Observations	3151	3151	3151	3151
R-squared	0.139	0.157	0.109	0.118

This Table reports results from pooled and industry fixed-effects unconditional quantile regressions using Tobin's Q as the dependent variable and a set of firm characteristics as explanatory variables for the 10% and 90% quantile. 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 7

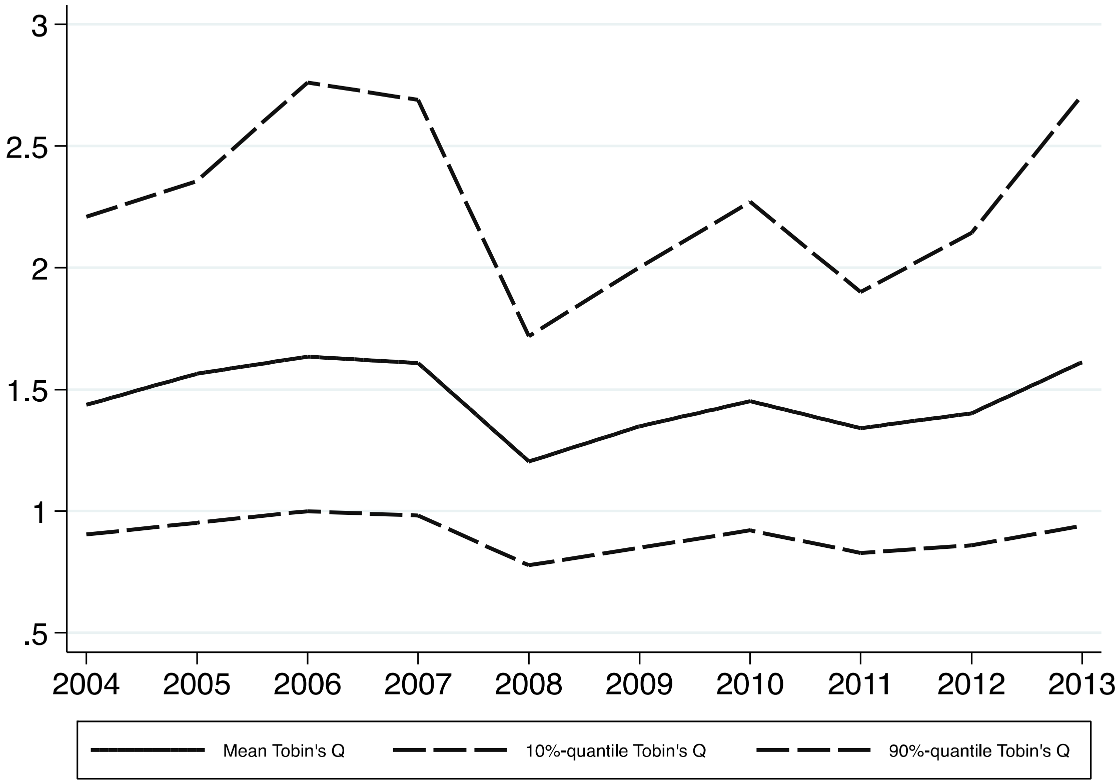
Tobin's Q, FX derivatives ratio and firm characteristics: fixed-effects and unconditional quantile regressions

	Fixed-effects regression	UQR regression with fixed-effects: 10% quantile	UQR regression with fixed-effects: 90% quantile
Variable name	(1)	(2)	(3)
Notional FX derivatives / total assets	0.236* (2.105)	0.040 (0.493)	0.509** (2.462)
Size	-0.028** (-2.767)	0.005 (0.831)	-0.086*** (-5.178)
Quick ratio	0.000*** (9.393)	0.000 (0.147)	0.001 (0.306)
Debt ratio	0.166* (1.835)	0.465*** (7.165)	-0.041 (-0.208)
Dividend	0.141*** (5.453)	0.114*** (5.120)	0.215*** (3.905)
Return on assets	0.508** (2.616)	0.332*** (3.927)	1.188*** (3.511)
Capital expenditures / sales	-0.183 (-1.355)	-0.157 (-1.269)	-0.078 (-0.346)
R&D / sales	1.383*** (4.628)	0.383** (2.333)	3.596*** (5.015)
Industrial diversification	0.021 (0.336)	-0.017 (-0.920)	0.146** (2.501)
Geographic diversification	-0.007 (-0.067)	0.005 (0.155)	-0.103 (-1.060)
Industry Q (log)	0.980*** (15.707)	0.772*** (4.778)	1.322*** (3.391)
Intercept	0.063 (0.502)	-0.697*** (-5.058)	0.835*** (3.472)
Observations	2889	2889	2889
R-squared	0.171	0.158	0.115

This Table reports results from industry fixed-effects regression (1) and unconditional quantile regressions (UQR) with industry fixed-effects for the 10% and 90% quantile (2 and 3) using Tobin's Q as the dependent variable and a set of firm characteristics as explanatory variables. T-statistics are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using cluster-robust standard errors (1) and robust standard errors bootstrapped from 1,000 replications (2 and 3), respectively.

Figure 1

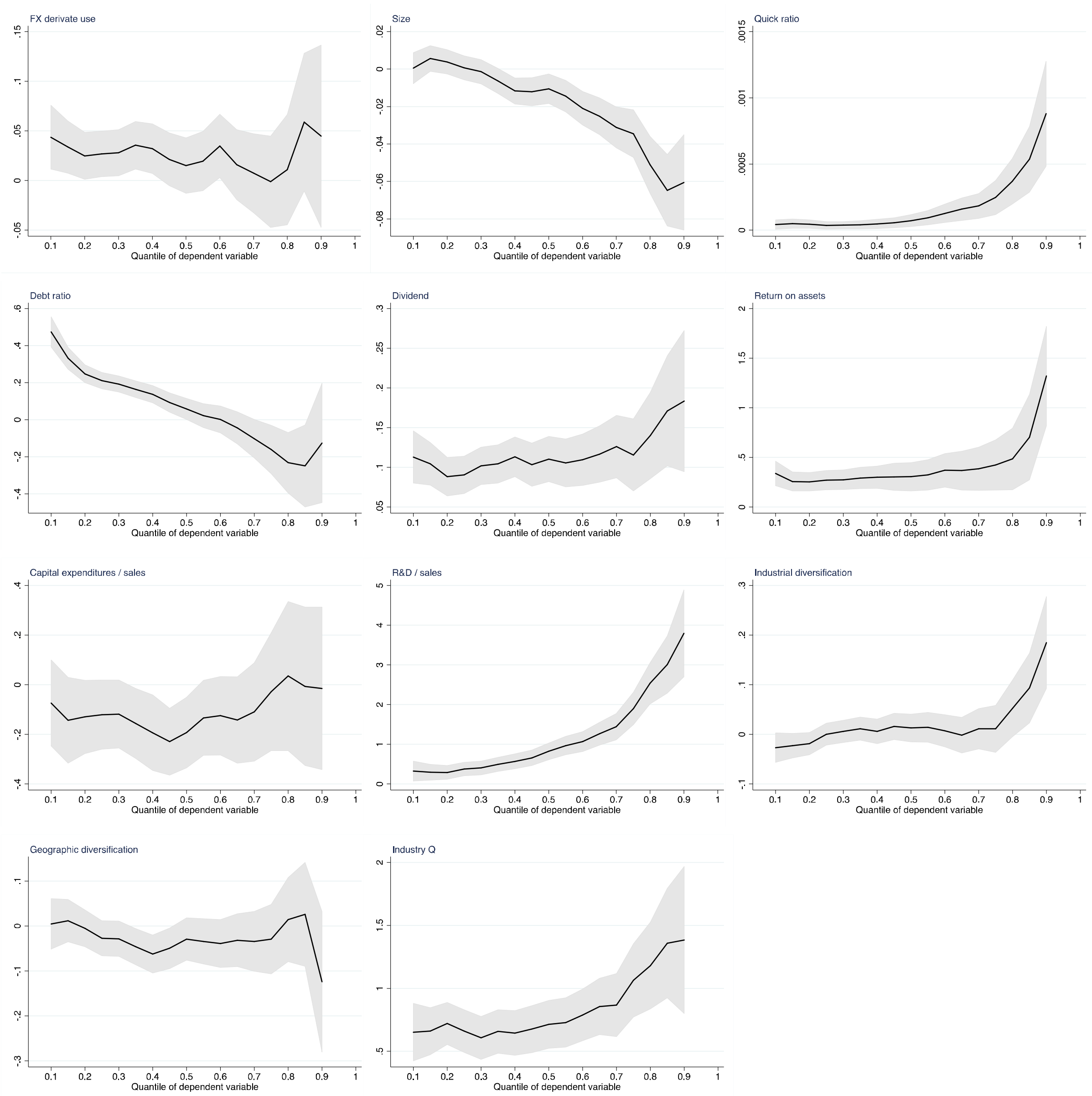
Development of cross-sectional distribution of Tobin's Q over time



This Figure shows the development of the cross-sectional distribution of Tobin's Q for means, 10% and 90% quantiles over the sample.

Figure 2

Unconditional quantile regression: Coefficients over quantiles



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 industry fixed-effects unconditional quantile regression using Tobin's Q as the dependent variable and a set of firm characteristics as explanatory variables for unconditional quantiles from the 10% to the 90% quantile of Tobin's Q distribution.

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