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Operational and Financial Hedging: Evidence from Export and Import Behavior

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Abstract

We use hand-collected data on a sample of German public firms during 2011-2014 to show that firms use currency derivatives more often when they export or import, and especially when exchange-rate fluctuations are larger, but to a lesser extent when having high export and import shares simultaneously. We interpret this finding as evidence of operational hedging that arises as foreign-denominated revenues and costs match, and substitutes for financial hedging. Our identification strategy uses both cross-sectional heterogeneity in exchange-rate exposures and time-series variation in exchange-rate fluctuations. We highlight the importance of examining operating strategies as integral determinants of corporate financing policies.

Keywords: Hedging, Exporting, Operational hedging, Exchange-rate exposure

JEL codes: D22, F36, G32

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1 Introduction

Bartram et al. (2009) report that about 60% of non-financial firms around the world use financial derivatives, with the most popular type being currency derivatives (44%). These significant numbers indicate the importance of risk management in general and hedging exchange-rate shocks in particular. However, the literature has also suggested that, besides financial hedging, firms may also use *operational* hedging to reduce their cash-flow volatility, e.g. by diversifying their operations and production geographically (as in Allayannis et al., 2001, and Kim et al., 2006) or by acquiring subsidiaries (as in Hankins, 2011). In this paper, we explore a different type of operational hedging – the one arising from exporting the final goods and importing intermediate inputs from abroad at the same time.

Although several papers have considered a correlation between export sales and hedging behavior (e.g. Géczy et al., 1997, He and Ng, 1998, Allayannis and Ofek, 2001), we are not aware of any paper that would model jointly the export and import exposure to exchange-rate fluctuations and illustrate how an operational hedge through matching foreign-currency-denominated revenues with foreign-currency-denominated costs affects financial hedging. Our paper fills this gap.

We show that firms hedge more when they are more exposed to exchange-rate fluctuations through exporting and importing, and particularly during times when these fluctuations are higher. However, we also find that they hedge less when they have high export and import shares at the same time. We interpret this finding as evidence of operational hedging that arises when foreign-denominated revenues and costs match, substituting for financial hedging with currency derivatives.

To identify the effect of interest, we use the difference-in-differences approach that employs both cross-sectional heterogeneity in exchange-rate exposures and time-series variation in exchange-rate fluctuations, controlling for year and firm fixed effects. The economic magnitude of the effect suggests that for a firm in an industry with a 10 percentage points higher export share, an additional 10 percentage point increase in import share results in about a 9 percentage point lower increase in hedging probability.

So why and how can export and import activities affect hedging with currency derivatives, and why simultaneous exporting and importing could lead to less financial hedging? In a highly globalized world, the exchange rate is directly connected to the so-called transaction exposure of companies (Glaum, 2005). It arises when companies have contractual arrangements in foreign currencies. In particular, when a company exports goods or imports intermediate inputs under foreign-denominated contract obligations, it becomes exposed to the movements of foreign exchange rates – in terms of the need to translate these revenues and costs into domestic currency when the transaction clears in the future. As long as volatility is costly for firms, higher exchange-rate exposure leads to more financial hedging. However, when firms both export and import at the same time, their net foreign-denominated position (and thus exchange-rate exposure) becomes lower, and thus there is less incentive to hedge against it.

To test our hypotheses, we use hand-collected data on a sample of German public firms during 2011-2014. Germany provides a particularly interesting laboratory for testing our hypotheses for at least three reasons.

First of all, it is the world's third largest exporter and importer and the top one in Europe. Second, the share of German exports and imports outside the euro area (out of total export and import) is high. According to the German Federal Statistical Office, it constitutes more than 60% for both export and import as of 2014. Moreover, as reported by Goldberg and Tille (2008), more than half of German exports and imports outside the euro area are denominated in foreign currencies, and in particular about 30-40% of all contracts are set in U.S. dollars. A similar figure for the U.S., for example, shows that only 5% of all contracts are set in a currency other than the U.S. dollar. This means that our measured shares of non-euro zone exports and imports will actually have a large component of non-euro-denominated contracts, and we will have more power in measuring the exchange-rate exposure arising from exporting and importing.

Finally, the largest companies in Germany, which we analyze in our paper, trade on the Prime Standard segment of the Frankfurt Stock Exchange, which has the highest requirements in terms of international accounting and transparency, and in particular makes firms disclose their use of derivatives. This enables us to collect the data on hedging from companies' annual reports and perform the analysis.

The contribution of our paper is threefold. First, we show that exchange-rate volatility is hedged by firms. We do not rely on simple time-series correlations, which may be corroborated by omitted variable bias, but instead directly show that firms that are more exposed to exchange-rate volatility through their operations are also more likely to use currency derivatives. Importantly, we show that they use them even more when exchange-rate volatility is higher. Additionally, by exploring cross-sectional heterogeneity of the effect and a placebo test using interest-rate derivatives, we rule out alternative mechanisms in our sample, such as the use of derivatives for speculative reasons.

Second and more interesting, we are, to the best of our knowledge, first to show that simultaneously high activity in export and import markets creates an operational hedge which substitutes for financial hedging. Again, this operational hedge becomes more important when exchange-rate volatility gets higher. Finally, we extend the existing literature by using a new sample of firms that is relatively large compared to other hand-collected data and surveys. More importantly, it is a panel rather than a cross-section, allowing us to identify all of the effects of interest using within-firm variation only.

Our paper also relates to the literature on the so called "exposure puzzle" – an empirical observation of the relatively low correlation of exchange-rate exposures with firm value, stock returns, and/or cash flow volatility (Jorion, 1990, Bartov and Bodnar, 1994, Griffin and Stulz, 2001, Bartram, 2008). This empirical finding appears to contradict theoretical predictions on the effect of risk exposure on firm value: as long as the assumptions of Modigliani and Miller (1958) are violated, this exposure should matter and there should be a scope for hedging[3]. Furthermore, surveys of hedging be-

[3]The literature has explored various market imperfections that give rise to value-enhancing risk-management, including the existence of financial distress costs (Smith and Stulz, 1985); costly external financing and the underinvestment problem (Froot et al., 1993); tax convexity (Smith and Stulz, 1985; Nance et al., 1993; Graham and Rogers, 2002); information assymetry and agency costs (Smith and Stulz, 1985; DeMarzo and Duffie, 1995; Breeden and Viswanathan, 1998).

havior (Bodnar et al., 1995; Glaum, 2005) indicate that firms are primarily concerned with uncertainty arising from macroeconomic factors (including the exchange rate) and its effect on cash-flow volatility, and hence firm value.

A possible explanation for this apparent contradiction is offered by Bartram and Bodnar (2007). They suggest that because financial and operational hedging adjust endogenously to different exchange-rate exposures, in equilibrium there may be only a weak relation between exposure and value. Our paper is consistent with this view, as it illustrates how a different exchange-rate exposure triggers a different operational hedging behavior, which then substitutes for financial hedging.

Interestingly, the above argument also makes a direct assessment of the effect of hedging on the resulting cash-flow volatility controversial, since hedging is an endogenous choice variable. We thus use an alternative approach to testing whether hedging adjusts optimally to a changing exchange-rate exposure. In particular, we show that when the volatility of the exchange rate (exogenously) increases, firms that have higher exposure are more likely to use currency derivatives.

From a more global perspective, our paper highlights the interplay between operating and financial policies of corporations. As such, it is a part of a larger literature that has modeled how real policies aimed at lowering operational risks (or alternatively increasing operating flexibility) reflect in various financial decisions (such as e.g. capital structure). Examples of such policies include the use of flexible manufacturing systems that allow changing the level of output, the product mix, or the operating "mode" (as in Brennan and Schwartz, 1985; He and Pindyck, 1992; and Kulatilaka and Trigeorgis, 2004); employing a contingent workforce (e.g. part-time and seasonal labor, as in Hanka, 1998 or workers on temporary contracts, as in Kuzmina, 2014); adopting a defined contribution, rather than a defined benefit, pension plan (as in Petersen, 1994); and many others. From the applied perspective, such interdependencies support the complementarity of the CEO's and CFO's decision-making. From the policy perspective, they imply that exogenous changes in government policies aimed at certain organizational changes in the firm (e.g. export promotion policies) could have indirect consequences for their riskiness and financing decisions.

The paper proceeds as follows: Section 2 describes the data and defines the variables; Section 3 describes our empirical strategy; Section 4 presents the main results of the paper; Section 5 tests for the hedging (rather than speculative) mechanism behind our results; and Section 6 concludes.

2 Data Description and Variables Definition

The results in our paper are based on four sets of data. We combine our hand-collected data on firms' use of derivatives with the data on their financial indicators as well as the data on export and import intensities of various industries and the data on exchange rates.

2.1 Derivatives data

We are not aware of any database that would consistently report the use of different types of derivatives by firm, and according to Bartram et al. (2009), until recent years the disclosure largely remained voluntary. In this paper we analyze German public non-financial firms that are listed in the Prime Standard on Frankfurt Stock Exchange, during the period 2011-2014. This sample of firms provides an excellent opportunity to explore hedging policies of firms because of the distinguishing feature of Prime Standard listing: firms are subject to an extended list of requirements including the highest level of disclosure and international transparency standards (including publication of their annnual reports in English). This allows us to collect the necessary information, including the use of interest-rate (IR) derivatives, commodity-prices (CP) derivatives, and currency (or foreign-exchange, FX) derivatives.[4]

We start with the list of 317 firms with a Prime Standard listing and then exclude companies from the utility industry because it is highly regulated, and financial institutions ("Banks", "Diversified Financials", "Insurance"), because they have different reasons to use derivatives than non-financial companies (in line with Allayannis et al. (2012)). We also exclude companies with IPOs later than 2011. Thus, the final sample consists of 230 companies, tracked in a panel over 4 years.

To collect the data on derivatives usage, we first screen the annual financial reports, available through Bloomberg and the official web-pages of the companies, for the following keywords: "derivative", "hedge", "hedging", "foreign currency", "swap", "forward", "option", "futures", "financial instruments", "commodity", "risks", "risk management", "exposure". Then we manually code a binary variable that equals 1 if the firm is using a particular type of derivative in a particular year, and 0 otherwise.

As reported in Table 1, about 76% of our firm-year observations use at least one type of derivatives, and about 59% use foreign-exchange derivatives. These numbers are consistent with the ones reported by Bartram et al. (2009) and Allayannis et al. (2012), who also use hand-collected

[4]For the purposes of this study, we consider the latter category only.

derivatives data, and Bodnar and Gebhardt (1999) who use survey data.

2.2 Exchange-rate exposure

In order to use our identification strategy we need to construct a measure of exposure to foreign-exchange risk so as to divide firms into more and less exposed groups. A natural candidate is the export and import behavior of firms, since these involve foreign revenues and costs, respectively. This is also consistent with the existing studies (Jorion, 1990; Bodnar and Gentry, 1993; Allayannis and Ofek, 2001; Bartram, 2007) that show a positive relation between exchange-rate exposure and foreign sales, and Bodnar and Gentry (1993) and Allayannis (1997) who provide evidence of a significant relation between real operations (import and export) of U.S. firms (at industry level) and their exposure to currency fluctuations.

Although using actual firm-level export and import amounts may seem attractive, such data are generally harder to obtain – especially since we are interested specifically in export and import transactions not in euro, which generate exchange-rate exposure. But more importantly, such firm-level measures are likely to be highly endogenous. In particular, firms that have higher opportunitites to hedge their exchange-rate exposure (e.g. due to unobserved profitability shocks, etc) may be more likely to export and/or import. This would result in an omitted variable bias and make the estimates of the coefficients of interest inconsistent. It is thus important to use measures that would suffer less from such concerns.

We overcome this potential problem by using industry-level measures of exporting and importing. This is also consistent with Bodnar and Gentry (1993), who show that industrial characteristics systematically determine the extent of exchange-rate exposure. In particular, we use the ratio of export sales (to non-euro countries) to total sales and the ratio of imported inputs (from non-euro countries) to total purchased intermediate inputs, at the industry level, for 2011. Using a fixed base year further ensures that we do not capture the endogenous time-varying exporting and importing decisions of firms.

We construct the ratio of imported inputs using the Input-Output table for 2011 (OECD (2011) and WIOT (2011)) by counting imported inputs by German industries from all countries outside of the euro zone. Similarly, we count the amount of export by German industries to all countries outside of the euro zone and calculate the ratio of export sales to total output by industry. By doing this for both OECD and WIOT, and combining the classifications (as each is more detailed in some respects than the other one), we get an estimate of export and import exposure for 39 industries.

They roughly correspond to 2-digit ISIC Rev3 classification, and 28 of them can be matched to firms in our data. Table 2 lists the obtained measures together with the number of observations in each industry. These data are then matched to the firm-level data at the industry level.

As we see from Table 1, on average about 23% of firms' sales in our sample are exported to non-euro countries. This figure is comparable to the overall German export share to non-euro countries of 29% in 2014, as reported by German Federal Ministry BMWi (2014). About 15% of total inputs is imported from non-euro countries on average.

2.3 Exchange-rate volatility

We now proceed by constructing a measure of exchange-rate shock. We are primarily interested in a symmetric measure, since firms may hedge against currency appreciation or depreciation, depending on whether they receive foreign revenues or pay foreign costs. Exchange-rate volatility is thus a natural candidate, especially since it is a common measure of total risk. Also, according to Bartov et al. (1996) the rise of exchange-rate volatility increases the volatility of stock returns and adds systematic risk, raising the companies' cost of capital. Consequently, firms face an undesirable and negative effect on cash-flow volatility due to exchange-rate fluctuations.

Moreover, Brown (2001) shows in his case study of a U.S. corporation that decisions regarding FX hedging volumes depend among other things on exchange-rate volatility.

Like previous studies (Bodnar and Gentry, 1993, and He and Ng, 1998, among others), we use a (trade-weighted) nominal effective exchange-rate index for each year:

$$NEER_t = \prod_{i=1}^{N} (e_{i,t,euro})^{w_i}$$

where $e_{i,t,euro}$ is an index of the average daily exchange rate of the currency of trading partner i against the euro in period t (in terms of foreign currency per euro); w_i is the trade weight assigned to the currency of trading partner i; and N is the number of trading partners (see ECB (2017) Statistics Bulletin, Note to Tables 8.1 for more details).

We take bilateral nominal exchange rates for 36 trading partners from the European Central Bank Statistical Data Warehouse (ECB (2014)) and trade weights based on 2007-2009, the years before the considered period to eliminate endogeneity issues. These trade weights come from Schmitz et al. (2012). We proportionately recalculate them, since the ECB exchange-rate data are not available for Chile, Iceland, and Venezuela, and report them in Table A.1 in the Appendix. An increase (decrease) of the index means appreciation (depreciation) of the euro.

Finally, we calculate the realized exchange-rate volatility:

$$Vol_t = \sqrt{\frac{252}{n} * \sum_{i=1}^{n} R_i^2}$$

where Vol_t is the realized annualized volatility of the one-year period; 252 is the approximate number of trading days in a year; R_i are log daily returns on the exchange rate index: $R_i = ln\frac{NEER_i}{NEER_{i-1}}$; and n is the number of actual trading days within the year.

As we note from Table 1, this exchange-rate volatility has a mean of 4.8% and ranges from 4.2% to 6.1%, annualized.

2.4 Control variables

Finally, we obtain the data on some of the popular control variables used in the hedging literature (Sales, Return on assets, as well as financial rations to calculate the Altman (1968) z-score), and the industry identifier from Bloomberg. Although our identification strategy does not require the use of controls, they can help in explaining additional variation in the hedging behavior of firms.

We use the natural logarithm of firm's sales as a proxy for its size. A significant number of empirical studies (Géczy et al., 1997, Bodnar and

Gebhardt, 1999, Graham and Rogers, 2002, Bartram et al., 2009 among others) document that larger firms are more likely to use derivatives. The explanation is that implementation of risk management policy, and especially hedging with derivatives, is costly, and larger firms have higher economies of scale in allocating funds for risk management. Also, He and Ng (1998) provide evidence that bigger firms have an additional motivation to hedge due to their higher exposure to foreign-exchange risk.

As reported in Table 1, firms in our sample are relatively large on average (which is expected given their Prime Standard listing). In particular, an average log of firm's sales is equal to about 20, which corresponds to about 0.5bln euro.

Following Allayannis and Ofek (2001), we also use Return on assets, defined as Net Income over Total Assets, as a proxy for profitability. An average firm in our data has about 2 percent ROA, with a twice higher median value. The idea for using this control variable is that more profitable firms typically have less problems with meeting their financial obligations, and hence have less incentives to hedge shocks. We thus expect a negative coefficient for this variable.

Finally, we also add Altman (1968) z-score, as a measure of distance to distress. It is measured as a weighted sum of five financial ratios, with a higher number (preferably above 2.99) proxying for a "safe" company that is less likely to default in future. We would expect firms closer to default to hedge more (as it is relatively more important for them), and at the same time firms that hedge should do so to decrease their probability of default. Given that this is used just as a covariate in the regression (rather than a causal variable), either argument could be true, and there is no specific expectation on the sign of this variable.

3 Empirical strategy

We test our hypotheses in a linear regression model where the identification strategy is similar to the difference-in-differences approach. In particular, we estimate a set of specifications with the fullest one being the following:

$$\begin{aligned} FX_{it} = \alpha_i + \alpha_t + \beta_1 Ex_{s0} * Vol_t + \beta_2 Im_{s0} * Vol_t \\ + \beta_3 Ex_{s0} * Im_{s0} * Vol_t + \gamma' X_{it} + \varepsilon_{it} \end{aligned} \tag{1}$$

where FX_{it} is a binary variable equal to 1 if firm i uses FX derivatives in year t, and 0 otherwise; Ex_{s0} is the ratio of export sales to non-euro countries to total sales in industry s in base year 0; Im_{s0} is the ratio of imported (from non-euro countries) inputs to total intermediate inputs used by industry s in base year 0; Vol_t is the annualized volatility of trade-weighted euro exchange-rate index in year t; X_{it} is a vector of time-variant control variables for firm i in year t; α_i and α_t are firm and year fixed effects.

Importantly, since the main variables of interest vary at the industry-year level, we cluster standard errors at the industry level throughout the analysis. This is done to account for potential within-industry and across-time correlation.

Note that variables Ex_{s0}, Im_{s0} (and $Ex_{s0} * Im_{s0}$) are included in all specifications – either as controls, or automatically subsumed by industry or firm fixed effects. These variables capture potential differences between firms that have a higher value of these ratios, and are thus more exposed to exchange-rate movements, and those with a lower value and a lower exposure.

In order to give our results a causal flavor, we adapt the difference-in-differences methodology and include the interactions of Ex_{s0} and Im_{s0} with the volatility of exchange rate, Vol_t. Since the unobserved cross-sectional differences across firms that may correlate with exchange-rate exposure itself are captured by Ex_{s0} and Im_{s0}, the coefiicients of interest β_1 and β_2 now measure whether firms that are more exposed to exchange-rate fluctuations actually hedge more *when these fluctuations are (exogenously)* *higher*. This approach relies on both cross-sectional and time-series sources of variation, and allows us to directly test whether firms hedge exchange-rate fluctuations using FX derivatives in a quasi-experimental setup.

We further add the triple interaction between Ex_{s0}, Im_{s0}, and Vol_t. The coefficient of interest, β_3, measures whether firms that are exposed to exchange rate movements both on their revenue side (through exporting outputs) and their cost side (through importing inputs) hedge less when the exchange rate is more volatile, as compared to firms that do not match their exposure on both sides. This interaction is again considered in a difference-in-differences framework, and allows us to test whether firms' operational hedging through matching currency of revenues and costs (foreign vs domestic) is a substitute for financial hedging.

Finally, in some of our specifications, we complement our identifiation strategy by using a set of control variables (such as size, profitability and distance to default) in order to explain some of the variation across firms with various determinants of finanical hedging; and a full set of fixed effects to additionally control for any time-invariant firm heterogeneity and for common macroeconomic shocks affecting firms.

4 Hedging exchange-rate volatility: Results

4.1 Cross-sectional comparison

We begin by providing some simple cross-sectional comparisons. Table 3 reports the results of estimating a specification where the interaction terms with volatility are not included. It shows basic correlations between the exposure to exchange rate fluctuations (through exporting and/or importing) and the use of FX derivatives. All specifications include year fixed effects to account for any macroeconomic shocks (such as, for example, related to the interest rate, etc) common to all firms. The standard errors are clustered at industry level and are robust to heteroskedasticity and arbitrary within-industry correlation.

The coefficient in Column 1 is significant at the 1% level and indicates that, controlling for year fixed effects, firms in industries with higher export shares hedge more. In particular, a one-standard deviation increase in the export share is associated with $0.185 * 1.053 * 100 = 19.5$ percentage points higher probability of using FX derivatives. Similarly, Column 2 indicates that firms in industries with higher import shares hedge more. In particular, a one-standard deviation increase in the import share is associated with $0.065 * 2.895 * 100 = 18.8$ percentage points higher probability of using

FX derivatives.

As we see from Table 2, many industries simultaneously export and import a lot. Some, however, such as Construction or Post and Telecommunications, have a substantial imbalance in terms of export and import shares. This is reasonable given the nature of the goods and services that they produce. We are, however, interested in whether this translates into different hedging behavior. In Column 3, we add the interaction between export and import shares and see that it is negative and signifiant at the 5% level. This suggests that firms that simultaneously export and import hedge less than firms that just export or import. This is consistent with our hypothesis that firms decrease their effective exchange-rate exposure by having both revenues and costs in foreign currency and implies that operational hedging through matched currencies is a substitute for financial hedging. The magnitude of this coefficient suggests that for an industry with a 0.1 higher export share, an additional 0.1 increase in import share results in an 8.9 percentage points lower increase in hedging probability.

Finally, in Column 4 we add firm control variables to account for potential differences in firm size, profitability and distance to distress and see similar results. The interaction between the share of export and import is still negative and significant (at the 10% level), and the control variables have the expected signs, consistent with the discussed literature: larger firms hedge more, more profitable firms hedge less, while "safe" firms that are far from distress hedge more.

These correlations can provide only suggestive cross-sectional evidence, as they are likely to suffer from omitted variable bias. Hence, we proceed with our difference-in-differences approach, as described in detail in Section 3, in order to see whether firms in industries that are exposed differently to exchange-rate fluctuations actually hedge differently when exchange-rate shocks arrive.

4.2 Difference-in-differences comparison

We report the results of estimating specification (1) (with different combinations of fixed effects and control variables) in Table 4. The coefficients of interest are the first three, where the export and import shares are interacted with exchange rate volatility. They show how different firms change their hedging behavior in response to exogenous changes in volatility.

Column 1 reports the results of estimating (1) with year fixed effects only and no control variables. This is a classic difference-in-differences specification, where cross-sectional variables (export share, import share, and their interaction) are included directly and the exchange-rate volatility is subsumed by year fixed effects. The coefficients indicate that firms hedge more when volatility rises[5] but do so in a very different manner.

In particular, the interaction terms of export and import shares with volatility are positive, with the latter being statistically significant at the 5% level. This is consistent with our cross-sectional finding that higher exchange-rate exposure through more export or import is associated with more hedging. The difference-in-differences specification allows us to test it in a finer way. It shows that fiirms that are more exposed to exchange-rate volatility hedge more than those less exposed, especially during the times of higher volatility.

However, more interestingly, the firms that are least sensitive to exchange-rate fluctuations are the firms with the highest export and import shares simultaneously, as indicated by the negative triple-interaction coefficient of -96.443, which is significant at the 5% level. Its economic magnitude suggests that for a firm with an average industry export share, an additional 10 percentage point increase in import share brings an increase in hedging by $(45.186 - 96.443 * 0.233) * 0.1 * 0.01 * 100 = 2.27$ percentage points when exchange-rate volatility increases by 1 percentage point (roughly comparable to its average yearly change). This amount falls by 0.96 percentage

[5] $\hat{\beta}_1 * Ex_{s0} + \hat{\beta}_2 * Im_{s0} + \hat{\beta}_3 * Ex_{s0} * Im_{s0} > 0$ for all values of Ex_{s0} and Im_{s0}, except for the "Leather and Footwear" industry.

points for each 10 percentage point increase in export share.

These results indicate that although firms hedge more when volatility increases, they do so to a lesser extent when having high export and import shares simultaneously. This is consistent with our hypothesis of operational hedging – through the use of export cash flows to cover import expenses – reducing the effective exchange-rate exposure of firms, which is reflected in a relatively lower use of FX derivatives. In this sense, operational and financial hedging appear to be substitutes.

We proceed by saturating our specification with fixed effects and firm control variables. Column 2 adds size, profitability, and z-score variables, and they continue having expected signs. The magnitude of the size coefficient suggests that firms with 10% higher sales on average have a 1.22 percentage point higher probability of hedging. The coefficients of interest are similar, with the triple-interaction being significant at the 10% level. Controlling for size is also important in respect of the large international economics literature, both theoretical and empirical, that indicates that exporters are the largest firms in the cross-section (e.g. Melitz (2003) among many). Since our results are robust to including size, they cannot be explained by accidentally picking larger firms (who export and import more and hedge more).

Column 3 adds industry fixed effects. As we see, the coefficients' economic and statistical significance remains the same. Industry fixed effects naturally subsume our cross-sectional exposure variables, but more importantly, they also help in controlling for any time-invariant industry characteristics that might affect hedging and bias our results. For example, the different nature of assets and different average volatility of cash flows across industries – for other operational reasons – are automatically captured in these specifications.

Finally, we saturate our specification as much as possible by adding firm fixed effects in column 4. It provides a very tight identification, since firm fixed effects capture all time-invariant firm heterogeneity that is potentially related to hedging behavior. In particular, our results cannot be explained by e.g. firms having different opportunitites to access the derivatives market, or different attitudes towards risk, or simply being different firms to start with. Importantly, this specification identifies only within-firm changes in hedging behavior, and still the main coefficient of interest remains significant at the 5% level, and with a similar economic magnitude. Notably, none of the control variables are significant in this specification any more, suggesting that only cross-sectional variation in firms' sizes, profitability and distance to distress is reflected in hedging behavior, while their yearly within-firm changes are not.

Since our dependent variable is binary, we have also conducted regressions using logit specifications, as a robustness check. The results are the same in terms of statistical significance and are reported in Appendix Table A.2. Given that the economic magnitudes in some non-linear specifications, including (conditional) logit with fixed effects, are hardly interpretable – as marginal effects are not computable (Cameron and Miller, 2015), as well as such specifications yielding potentially inconsistent estimates when using standard errors robust to heteroskedasticity and autocorrelation, we opt for linear specifications in the main body of the paper.

5 Exploring the economic mechanism: Hedging vs. speculation

5.1 Cross-sectional heterogeneity in distress costs

So far our results indicate that firms that are less exposed to currency fluctuations through the basket of their inputs and outputs (i.e. those that export and import in a foreign currency at the same time) use currency derivatives less. One might argue that they do so for speculative rather than hedging motives – e.g. for some unobservable reason that happens to correlate with simultaneous exporting and importing particularly during times when exchange-rate fluctuations are high[6]. In order to shed light on the economic mechanism behind our results we now explore cross-sectional heterogeneity in the effect of interest.

To do so we additionally interact our coefficient of interest β_3 in specification (1) with dummy variables $High_{it}$ and Low_{it}, which proxy for high and low costs of financial distress, respectively. This is analogous to subsample tests, with the following idea. If firms use derivatives for hedging purposes (rather than for speculative reasons), then the substitution effect among different types of hedging (operational through export-import combination vs financial through derivatives) should be stronger for firms that would benefit the most from hedging, i.e. for firms with high costs of financial distress.

We use several proxies for costs of financial distress in this analysis and report the estimation results in Table 5 columns 2 to 4. First we define firms to have $High_{it} = 1$ if their Altman z-score is below their industry median (column 2). The idea behind adjusting for industry is that there might be some common time-varying industry shocks that make all firms

[6]Importantly, the strength of our indentification strategy is that any alternative explanation would have to correlate with simultaneous exporting and importing precisely during high-volatility times, not just on average, since that is captured by firm fixed effects.

otherwise appear to be more vulnerable to default. Then, in column 3, we use a more conventional measure and define firms to have $High_{it} = 1$ if their Altman z-score is below 2.99 (i.e. they are not "safe" firms). Finally, in column 4, we use a different measure that relates to the (high) share of intangible assets. These assets are typically less redeployable (Williamson, 1988) and are thus associated with higher expected distress costs (see e.g. Frank and Goyal, 2009).

Taking the first proxy in column 2 we observe that the effect of interest for high distress costs, -149.054, is statistically significant at 1% level. At the same time the one for low distress costs firms, -75.108, is much lower in absolute magnitude and not significant. This suggests that only the firms for which hedging is indeed important (the high distress costs firms) substitute currency derivatives for operational hedging during high-volatility times. Moreover, the implied difference between high and low distress costs firms is statistically significant at 10% level, suggesting that the effect for high distress costs is statistically larger.

In columns 3 and 4 we use the other two proxies and the results are very similar, both in terms of economic magnitudes and statistical significance. Taken together they highlight the importance of hedging mechanism for explaining the differential use of currency derivatives depending on foreign currency exposures from input and output sides of the firm business.

5.2 Placebo test using interest-rate derivatives

Our last piece of evidence towards hedging employs the use of interest-rate derivatives as a placebo test. If it were for speculation purposes that firms use derivatives in a mannaer that correlates with simultaneous exporting and importing during high-volatility times, then we would expect to obtain similar results when using interest-rate derivatives as the dependent variable. We thus replicate our specifications from Table 4 using this other dependent variable.[7]

As expected, in none of the specfications the coefficient at the triple interaction is significant. Moreover, it is even of the opposite sign. This means that simultaneous exporting and importing in no way can substitute for the use of interest rate derivatives (unlike that of FX derivatives), suggesting that the speculative motive, or other omitted variables related to the general use of derivatives by firms, cannot explain our main findings.

[7] Unfortunately, we can do so only with interest-rate derivatives, but not with commodity derivatives, since the use of the latter cannot be identified separately from FX use for almost all firms in our sample. In particular, all but three firms that use commodity derivatives also use FX derivatives.

6 Conclusion

In this paper we have explored how the use of currency derivatives by firms depends on their exchange-rate exposure through exporting and importing. We find that firms tend to use these derivatives more frequently when having more exposure to foreign-exchange risks, and especially in response to increased exchange-rate volatility. This provides evidence that firms do hedge this volatility using currency derivatives. Interestingly, we also find that being a big exporter and importer at the same time reduces the likelihood of using such derivatives. We interpret this finding as the emergence of operational hedging due to netting out foreign-denominated revenues and costs, which in turn substitutes for financial hedging.

Our results are in line with studies finding a relatively low correlation between exchange-rate exposure and firm value. In particular, we suggest that in the presence of endogenous hedging (both financial and operational), firms can easily adapt to changes in exchange-rate risks.

In the future it would be interesting to explore how various constraints in accessing and using the derivatives market may preclude firms from perfect adjustment of their hedging behavior to exchange-rate shocks, thereby making them potentially more volatile and less valuable in the long run.

Such a mechanism would highlight yet another role of developed financial markets in the long-run survival and growth of corporations.

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Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
FX_{it}	0.591	0.492	0	1	920
CP_{it}	0.150	0.357	0	1	920
IR_{it}	0.563	0.496	0	1	920
Any_{it}	0.762	0.426	0	1	920
$Size_{it}$	20.050	2.303	13.153	25.072	918
ROA_{it}	0.020	0.135	-0.684	0.306	915
$Altman_{it}$	3.429	2.799	-3.477	18.360	883
Export share (Ex_{s0})	0.233	0.185	0.003	0.709	920
Import share (Im_{s0})	0.153	0.065	0.039	0.297	920
Exchange-rate volatility (Vol_t)	0.048	0.008	0.042	0.061	920

Table 2: Export and import shares by industry

	ISIC Rev.3 Industry	Export share	Import share	Number of observations
01-05	Agriculture, hunting, forestry and fishing	0.076	0.137	4
10-14	Mining and quarrying	0.188	0.212	4
15-16	Food, beverages and tobacco	0.103	0.134	4
17-18	Textiles and textile products	0.573	0.297	16
19	Leather and footwear	0.664	0.288	4
20	Wood and products of wood and cork	0.110	0.120	
21-22	Pulp, paper, printing and publishing	0.113	0.114	4
23	Coke, refined petroleum and nuclear fuel	0.115	0.501	
24	Chemicals and chemical products	0.397	0.199	60
25	Rubber and plastics products	0.273	0.194	
26	Other non-metallic mineral products	0.140	0.174	4
27	Basic metals	0.311	0.253	12
28	Fabricated metal products	0.152	0.147	
29	Machinery and equipment, n.e.c.	0.401	0.172	112
30, 32-33	Computer, electronic and optical products	0.454	0.236	136
31	Electrical machinery and apparatus n.e.c.	0.314	0.188	24
34	Motor vehicles, trailers and semi-trailers	0.323	0.153	12
35	Other transport equipment	0.436	0.237	44
36-37	Furniture, manufacturing n.e.c and recycling	0.138	0.186	32
40-41	Electricity, gas and water supply	0.081	0.203	
45	Construction	0.005	0.108	8
50	Sale, maintenance and repair of motor vehicles and motorcycles	0.006	0.113	
51	Wholesale trade and commission trade	0.072	0.100	36
52	Retail trade	0.004	0.077	36
55	Hotels and restaurants	0.046	0.084	
60	Inland transport	0.079	0.095	8
61	Water transport	0.709	0.097	4
62	Air transport	0.222	0.175	12
63	Supporting and auxiliary transport activities; activities of travel agencies	0.080	0.096	8
64	Post and telecommunications	0.032	0.111	32
65-67	Financial intermediation	0.082	0.052	
70	Real estate activities	0.004	0.039	52
71	Renting of machinery and equipment	0.035	0.082	
72	Computer and related activities	0.114	0.121	120
73-74	R&D and other business activities	0.066	0.089	88
75	Public administration and defence; compulsory social security	0.000	0.114	
80	Education	0.001	0.065	
85	Health and social Work	0.003	0.122	12
90-93	Other community, social and personal services	0.030	0.075	32

Table 3: Hedging of exporters and importers: cross-sectional approach

	(1) FX_{it}	(2) FX_{it}	(3) FX_{it}	(4) FX_{it}
Ex_{s0}	1.053***		2.082***	1.489**
	(0.283)		(0.638)	(0.608)
Im_{s0}		2.895***	3.351***	1.364
		(0.810)	(1.176)	(1.180)
$Ex_{s0} * Im_{s0}$			-8.902**	-5.175*
			(3.855)	(2.656)
$Size_{it}$				0.122***
				(0.012)
ROA_{it}				-0.383***
				(0.100)
$Altman_{it}$				0.009
				(0.008)
Year FE	YES	YES	YES	YES
$Adjusted R^2$	0.154	0.143	0.186	0.446
N	920	920	920	882

Robust standard errors clustered at the industry level in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Hedging in response to exchange rate shocks: difference-in-differences approach

	(1) FX_{it}	(2) FX_{it}	(3) FX_{it}	(4) FX_{it}
$Ex_{s0} * Vol_t$	6.390	4.737	7.793	10.563
	(6.074)	(8.611)	(9.031)	(9.511)
$Im_{s0} * Vol_t$	45.186*	41.922*	40.508	40.864
	(23.868)	(23.387)	(23.986)	(27.950)
$Ex_{s0} * Im_{s0} * Vol_t$	-96.443**	-85.629*	-96.803**	-101.153**
	(44.484)	(44.178)	(46.487)	(47.511)
Ex_{s0}	1.773**	1.260		
	(0.696)	(0.770)		
Im_{s0}	1.166	-0.660		
	(1.688)	(1.229)		
$Ex_{s0} * Im_{s0}$	-4.239	-1.040		
	(4.307)	(3.028)		
$Size_{it}$		0.122***	0.117***	-0.005
		(0.012)	(0.015)	(0.014)
ROA_{it}		-0.382***	-0.211	0.012
		(0.100)	(0.136)	(0.107)
$Altman_{it}$		0.009	-0.002	-0.007
		(0.008)	(0.007)	(0.009)
Year FE	YES	YES	YES	YES
Industry FE	NO	NO	YES	NO
Firm FE	NO	NO	NO	YES
$Adjusted R^2$	0.184	0.444	0.493	0.846
N	920	882	882	882

Robust standard errors clustered at the industry level in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Hedging in response to exchange rate shocks: Distress cost analysis

	(1) Base Table 4 column 4	(2) $HIGH_{it} =$ $\mathbb{1}$ {Altman score below ind. median}	(3) $HIGH_{it} =$ $\mathbb{1}$ {Altman score below 2.99}	(4) $HIGH_{it} =$ $\mathbb{1}$ {Intangibles/Assets above ind. median}
$Ex_{s0} * Vol_t$	10.563			
	(9.511)			
$Im_{s0} * Vol_t$	40.864			
	(27.950)			
$Ex_{s0} * Im_{s0} * Vol_t$	-101.153**			
	(47.511)			
$HIGH_{it} * Ex_{s0} * Vol_t$		10.637	18.676*	15.019
		(9.033)	(10.603)	(10.356)
$HIGH_{it} * Im_{s0} * Vol_t$		64.204*	56.148	65.483
		(33.651)	(33.898)	(39.904)
$HIGH_{it} * Ex_{s0} * Im_{s0} * Vol_t$		-149.054***	-164.370***	-152.565**
		(51.932)	(55.064)	(68.016)
$LOW_{it} * Ex_{s0} * Vol_t$		10.670	9.551	12.278
		(11.383)	(8.983)	(10.663)
$LOW_{it} * Im_{s0} * Vol_t$		29.114	33.187	36.770
		(24.767)	(25.127)	(39.603)
$LOW_{it} * Ex_{s0} * Im_{s0} * Vol_t$		-75.108	-74.439	-94.462
		(52.557)	(50.009)	(64.263)
$Size_{it}$	-0.005	-0.001	-0.007	-0.005
	(0.014)	(0.013)	(0.012)	(0.017)
ROA_{it}	0.012	0.022	0.021	0.021
	(0.107)	(0.102)	(0.107)	(0.105)
$Altman_{it}$	-0.007	-0.005	-0.007	-0.006
	(0.009)	(0.008)	(0.007)	(0.009)
Year FE	YES	YES	YES	YES
Industry FE	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES
$Within R^2$	0.009	0.011	0.016	0.015
N	882	882	882	827

Robust standard errors clustered at the industry level in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

		(2)	(3)	(4)
Implied difference		-73.946*	-89.931*	-58.104*
$HIGH_{it} * Ex_{s0} * Im_{s0} * Vol_t$ $-LOW_{it} * Ex_{s0} * Im_{s0} * Vol_t$		(41.212)	(44.398)	(30.892)

Table 6: The use of interest rate derivatives: placebo test

	(1) IR_{it}	(2) IR_{it}	(3) IR_{it}	(4) IR_{it}
$Ex_{s0} * Vol_t$	-16.309	-22.843	-23.440	-34.409
	(17.107)	(20.861)	(21.503)	(20.686)
$Im_{s0} * Vol_t$	40.072	64.257*	57.275	58.093
	(30.599)	(33.974)	57.275	(36.700)
$Ex_{s0} * Im_{s0} * Vol_t$	69.797	56.881	67.413	110.252
	(108.747)	(118.936)	(122.771)	(114.766)
Ex_{s0}	0.981	1.155		
	(1.336)	(1.375)		
Im_{s0}	-2.159	-5.258*		
	(2.546)	(2.658)		
$Ex_{s0} * Im_{s0}$	-3.161	-0.299		
	(7.806)	(7.961)		
$Size_{it}$		0.090***	0.098***	0.023
		(0.015)	(0.013)	(0.035)
ROA_{it}		0.017	0.026	-0.231**
		(0.170)	(0.139)	(0.097)
$Altman_{it}$		-0.030***	-0.025**	0.005
		(0.011)	(0.009)	(0.009)
Year FE	YES	YES	YES	YES
Industry FE	NO	NO	YES	NO
Firm FE	NO	NO	NO	YES
$Adjusted R^2$	-0.001	0.205	0.307	0.841
N	920	882	882	882

Robust standard errors clustered at the industry level in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A Appendix

Table A.1: Average trade weights for 2007 to 2009.

USD	0.136		HRK	0.005		MYR	0.011
JPY	0.058		RUB	0.035		NZD	0.001
BGN	0.005		TRY	0.031		PHP	0.003
CZK	0.041		AUD	0.007		SGD	0.012
DKK	0.021		BRL	0.014		THB	0.011
GBP	0.120		CAD	0.013		ZAR	0.010
HUF	0.026		CNY	0.149		ILS	0.007
PLN	0.051		HKD	0.014		TWD	0.015
RON	0.016		IDR	0.006		MAD	0.006
SEK	0.039		INR	0.022		ARS	0.003
CHF	0.054		KRW	0.032		DZK	0.004
NOK	0.011		MXN	0.012			

Table A.2: Hedging in response to exchange rate shocks: logit specifications

	(1)	(2)	(3)	(4)
	FX_{it}	FX_{it}	FX_{it}	FX_{it}
$Ex_{s0} * Vol_t$	30.333	80.264	235.015	1206.188
	(38.703)	(100.404)	(144.070)	(891.594)
$Im_{s0} * Vol_t$	235.100*	387.125**	885.479***	3281.363**
	(138.525)	(182.362)	(195.801)	(1593.696)
$Ex_{s0} * Im_{s0} * Vol_t$	-473.848**	-940.504**	-2314.675***	-9393.594**
	(220.116)	(409.203)	(553.960)	(4403.504)
Ex_{s0}	9.374**	8.182		
	(4.564)	(5.718)		
Im_{s0}	2.797	-9.453		
	(8.584)	(6.943)		
$Ex_{s0} * Im_{s0}$	-21.567	1.260		
	(23.500)	(21.007)		
$Size_{it}$		1.020***	1.022***	0.209
		(0.138)	(0.157)	(0.633)
ROA_{it}		-3.104**	-1.803	-0.452
		(1.465)	(1.549)	(3.248)
$Altman_{it}$		0.049	-0.043	-0.163
		(0.063)	(0.073)	(0.209)
Year FE	YES	YES	YES	YES
Industry FE	NO	NO	YES	NO
Firm FE	NO	NO	NO	YES
$PseudoR^2$	0.150	0.443	0.308	0.084
N	920	882	882	882

Robust standard errors clustered at the industry level in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$